UNCLASSIFIED

FY 2001 Budget Estimate Submission
DESCRIPTIVE SUMMARIES

September 15, 1999

DARPA

Defense Advanced Research Projects Agency

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DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Table of Contents

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Table of Contents (Cont'd)

SECTION I

FUNDING SUMMARIES

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE
PE/PROJECT LEVEL SUMMARY REPORT
($ in thousands)

PE	PROJ	TITLE	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
61101E	CCS-02	INFORMATION SCIENCES	16.201	18.892	20.953	30.700	30.700	30.700	30.700
	ES-01	ELECTRONIC SCIENCES	19.662	23.124	18.339	20.084	23.645	32.506	36.365
	MS-01	MATERIALS SCIENCES	25.523	22.277	34.000	34.053	31.053	25.053	14.053
	61101E	**DEFENSE RESEARCH SCIENCES**	**61.386**	**64.293**	**73.292**	**84.837**	**85.398**	**88.259**	**81.118**
62110E	**NGI-01**	**NEXT GENERATION INTERNET**	**42.430**	**40.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
62301E	ST-01	JASONS	1.188	1.200	1.200	1.200	1.200	1.200	1.200
	ST-11	INTELLIGENT SYSTEMS & SOFTWARE	85.512	77.018	90.200	75.100	62.536	74.393	68.034
	ST-19	HIGH PERFORMANCE & GLOBAL SCALE SYS	154.631	159.900	125.623	83.931	107.838	117.055	129.743
	ST-22	SOFTWARE ENGINEERING TECHNOLOGY	16.345	17.227	18.100	18.700	19.300	19.300	19.300
	ST-24	INFORMATION SURVIVABILITY	56.424	67.529	88.400	99.800	107.800	106.500	110.000
	ST-28	ASYMMETRIC THREAT	0.000	0.000	33.000	39.500	35.700	23.500	20.000
	62301E	**COMPUTING SYS & COMM TECHNOLOGY**	**314.100**	**322.874**	**356.523**	**318.231**	**334.374**	**341.948**	**348.277**
62302E	AE-01	DEEPLY NETWORKED SYSTEMS	0.000	25.000	13.700	13.000	27.000	32.000	42.000
	AE-02	SOFTWARE FOR AUTONOMOUS SYSTEMS	0.000	27.000	32.300	60.500	52.000	48.000	48.000
	AE-03	SOFTWARE FOR EMBEDDED SYSTEMS	0.000	18.000	24.000	28.000	12.000	15.000	10.000
	AE-04	GIGABYTE APPLICATIONS	0.000	0.000	30.000	20.000	20.000	15.000	10.000
	62302E	**EXTENSIBLE INFORMATION SYSTEMS**	**0.000**	**70.000**	**100.000**	**121.500**	**111.000**	**110.000**	**110.000**
62383E	**BW-01**	**BIOLOGICAL WARFARE DEFENSE**	**84.043**	**145.850**	**168.000**	**177.000**	**190.000**	**215.000**	**225.000**
62702E	TT-03	NAVAL WARFARE TECHNOLOGY	20.382	7.619	7.807	14.640	26.717	40.774	40.615
	TT-04	ADVANCED LAND SYSTEMS TECHNOLOGY	37.204	38.290	33.321	39.854	44.831	44.688	44.529
	TT-05	ADVANCED TARGETING TECHNOLOGY	0.000	0.000	0.000	8.400	16.700	26.700	36.700
	TT-06	ADVANCED TACTICAL TECHNOLOGY	44.823	40.244	32.463	47.968	47.673	43.530	43.371
	TT-07	AERONAUTICS TECHNOLOGY	29.888	31.385	29.346	18.168	35.593	45.450	49.291
	TT-10	ADVANCED LOGISTICS TECHNOLOGY	20.118	10.352	15.000	24.800	24.800	24.800	24.800
	TT-11	JOINT LOGISTICS ACTDS	9.294	9.736	10.000	10.000	0.000	0.000	0.000
	62702E	**TACTICAL TECHNOLOGY**	**161.709**	**137.626**	**127.937**	**163.830**	**196.314**	**225.942**	**239.306**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE
PE/PROJECT LEVEL SUMMARY REPORT
($ in thousands)

PE	PROJ	TITLE	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
62708E	**IC-03**	**INTERGRATED COMMAND & CONTROL TECH**	**38.612**	**31.296**	**32.000**	**0.000**	**0.000**	**0.000**	**0.000**
62712E	MPT-01	MATERIALS PROCESSING TECHNOLOGY	165.906	116.474	123.710	130.523	125.972	122.854	122.895
	MPT-02	MICROELECTRONIC DEVICE TECHNOLOGIES	83.369	92.301	71.216	70.094	63.358	73.215	83.056
	MPT-06	CRYOGENIC ELECTRONICS	17.731	26.546	21.335	15.168	9.945	9.802	9.643
	MPT-07	MILITARY MEDICAL/TRAUMA CARE TECH	2.973	0.000	0.000	0.000	0.000	0.000	0.000
	62712E	**MATERIALS & ELECTRONICS TECHNOLOGY**	**269.979**	**235.321**	**216.261**	**215.785**	**199.275**	**205.871**	**215.594**
63285E	**ASP-01**	**ADVANCED AEROSPACE SYSTEMS**	**0.000**	**19.664**	**24.000**	**28.000**	**30.000**	**20.986**	**19.986**
63739E	MT-03	UNCOOLED INTEGRATED SENSORS	12.473	10.791	12.000	7.000	0.000	0.000	0.000
	MT-04	ELECTRONIC MODULE TECHNOLOGY	60.755	56.686	35.650	35.149	39.667	38.029	34.829
	MT-05	TACTICAL INFORMATION SYSTEMS	32.112	20.205	15.600	23.100	16.000	0.000	0.000
	MT-06	MICROWAVE & ANALOG FRONT END TECH	3.809	0.000	0.000	0.000	0.000	0.000	0.000
	MT-07	CENTERS OF EXCELLENCE	6.062	4.000	0.000	0.000	0.000	0.000	0.000
	MT-08	MANUFACTURING TECHNOLOGY APPL	20.385	21.846	0.000	0.000	0.000	0.000	0.000
	MT-10	ADVANCED LITHOGRAPHY	48.026	39.000	44.900	45.000	45.000	45.000	45.000
	MT-12	MEMS	75.955	71.498	42.350	38.575	37.100	31.325	18.125
	MT-15	MIXED TECHNOLOGY INTEGRATION	0.000	21.997	42.500	46.010	50.000	50.000	50.000
	63739E	**ADVANCED ELECTRONICS TECHNOLOGY**	**259.577**	**246.023**	**193.000**	**194.834**	**187.767**	**164.354**	**147.954**
63747E	**EV-01**	**ELECTRIC VEHICLES**	**9.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
63760E	CCC-01	COMMAND & CONTROL INFORMATION SYS	82.299	108.133	70.787	87.734	106.234	114.034	119.834
	CCC-02	INFORMATION INTEGRATION SYSTEMS	87.071	114.755	69.593	39.749	32.246	35.012	35.837
	63760E	**COMMAND, CONT'L & COMMUNICATION SYS**	**169.370**	**222.888**	**140.380**	**127.483**	**138.480**	**149.046**	**155.671**
63761E	CST-01	ADVANCED SIMULATION	24.596	0.000	0.000	0.000	0.000	0.000	0.000
	CST-02	GLOBAL GRID COMMUNICATIONS	25.392	0.000	0.000	0.000	0.000	0.000	0.000
	63761E	**COMMUNICATION & SIMULATION TECH**	**49.988**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
63762E	SGT-01	GUIDANCE TECHNOLOGY	32.878	21.466	22.340	22.633	32.964	33.764	36.564

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE
PE/PROJECT LEVEL SUMMARY REPORT
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PE	PROJ	TITLE	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
	SGT-02	AEROSPACE SURVEILLANCE TECHNOLOGIES	65.465	77.712	67.438	89.798	100.232	84.500	109.300
	SGT-03	AIR DEFENSE INITIATIVE	24.430	42.350	23.471	19.960	30.000	38.000	38.200
	SGT-04	SENSORS & EXPLOITATION SYSTEMS	81.909	90.791	75.753	93.695	88.286	92.832	92.832
	63762E	**SENSOR & GUIDANCE TECHNOLOGY**	**204.682**	**232.319**	**189.002**	**226.086**	**251.482**	**249.096**	**276.896**
63763E	**MRN-02**	**MARINE TECHNOLOGY**	**24.779**	**22.538**	**34.964**	**48.396**	**55.896**	**55.696**	**60.496**
63764E	LNW-01	RAPID STRIKE FORCE TECHNOLOGY	43.632	53.223	52.867	56.177	47.000	42.000	42.000
	LNW-02	SMALL UNIT OPERATIONS	41.667	44.602	38.400	36.000	30.000	45.000	45.000
	63764E	**LAND WARFARE TECHNOLOGY**	**85.299**	**97.825**	**91.267**	**92.177**	**77.000**	**87.000**	**87.000**
63765E	**CLP-01**	**CLASSIFIED**	**48.797**	**77.780**	**97.600**	**99.800**	**79.100**	**65.000**	**55.000**
65114E	**BL-01**	**BLACKLITE**	**4.985**	**5.000**	**5.000**	**5.000**	**5.000**	**5.000**	**5.000**
65502E	**SB-01**	**SMALL BUSINESS**	**42.839**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
65898E	**MH-01**	**MANAGEMENT HEADQUARTERS (R&D)**	**32.898**	**31.387**	**34.632**	**35.944**	**37.373**	**38.634**	**38.922**
	AGENCY TOTAL		1904.473	2002.684	1883.858	1938.903	1978.459	2021.832	2066.220
	BA-01	**TOTAL**	**61.386**	**64.293**	**73.292**	**84.837**	**85.398**	**88.259**	**81.118**
	BA-02	**TOTAL**	**910.873**	**982.967**	**1,000.721**	**996.346**	**1,030.963**	**1,098.761**	**1,138.177**
	BA-03	**TOTAL**	**851.492**	**919.037**	**770.213**	**816.776**	**819.725**	**791.178**	**803.003**
	BA-06	**TOTAL**	**80.722**	**36.387**	**39.632**	**40.944**	**42.373**	**43.634**	**43.922**
	AGENCY TOTAL		**1,904.473**	**2,002.684**	**1,883.858**	**1,938.903**	**1,978.459**	**2,021.832**	**2,066.220**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE
PE LEVEL SUMMARY COMPARISON OF FY 2000 PRESIDENT'S BUDGET TO FY 2001 BUDGET ESTIMATES SUBMISSION
($ in millions)

PE	TITLE		FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
61101E	DEFENSE RESEARCH SCIENCES	FY 00 PB	64.429	64.293	68.792	69.837	75.398	78.259	81.118
		FY 01 BES	61.386	64.293	73.292	84.837	85.398	88.259	81.118
		Delta	**-3.043**	**0.000**	**4.500**	**15.000**	**10.000**	**10.000**	**0.000**
62110E	NEXT GENERATION INTERNET	FY 00 PB	49.504	40.000	0.000	0.000	0.000	0.000	0.000
		FY 01 BES	42.430	40.000	0.000	0.000	0.000	0.000	0.000
		Delta	**-7.074**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
62301E	COMPUTING SYS & COMM TECHNOLOGY	FY 00 PB	323.959	322.874	331.023	348.231	385.374	391.948	388.277
		FY 01 BES	314.100	322.874	356.523	318.231	334.374	341.948	348.277
		Delta	**-9.859**	**0.000**	**25.500**	**-30.000**	**-51.000**	**-50.000**	**-40.000**
62302E	EXTENSIBLE INFORMATION SYSTEMS	FY 00 PB	0.000	70.000	70.000	70.000	70.000	70.000	70.000
		FY 01 BES	0.000	70.000	100.000	121.500	111.000	110.000	110.000
		Delta	**0.000**	**0.000**	**30.000**	**51.500**	**41.000**	**40.000**	**40.000**
62383E	BIOLOGICAL WARFARE DEFENSE	FY 00 PB	84.754	145.850	151.000	151.500	135.800	116.800	113.800
		FY 01 BES	84.043	145.850	168.000	177.000	190.000	215.000	225.000
		Delta	**-0.711**	**0.000**	**17.000**	**25.500**	**54.200**	**98.200**	**111.200**
62702E	TACTICAL TECHNOLOGY	FY 00 PB	169.759	137.626	123.937	172.330	212.514	227.942	241.306
		FY 01 BES	161.709	137.626	127.937	163.830	196.314	225.942	239.306
		Delta	**-8.050**	**0.000**	**4.000**	**-8.500**	**-16.200**	**-2.000**	**-2.000**
62708E	INTERGRATED COMMAND & CONTROL TECH	FY 00 PB	39.607	31.296	32.000	0.000	0.000	0.000	0.000
		FY 01 BES	38.612	31.296	32.000	0.000	0.000	0.000	0.000
		Delta	**-0.995**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
62712E	MATERIALS & ELECTRONICS TECHNOLOGY	FY 00 PB	278.286	235.321	219.063	211.285	209.275	224.071	243.594
		FY 01 BES	269.979	235.321	216.261	215.785	199.275	205.871	215.594
		Delta	**-8.307**	**0.000**	**-2.802**	**4.500**	**-10.000**	**-18.200**	**-28.000**
63285E	ADVANCED AEROSPACE SYSTEMS	FY 00 PB	0.000	19.664	19.000	23.000	5.000	5.986	9.986
		FY 01 BES	0.000	19.664	24.000	28.000	30.000	20.986	19.986
		Delta	**0.000**	**0.000**	**5.000**	**5.000**	**25.000**	**15.000**	**10.000**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE
PE LEVEL SUMMARY COMPARISON OF FY 2000 PRESIDENT'S BUDGET TO FY 2001 BUDGET ESTIMATES SUBMISSION
($ in millions)

PE	TITLE		FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
63739E	ADVANCED ELECTRONICS TECHNOLOGY	FY 00 PB	265.442	246.023	233.198	232.534	247.767	259.354	258.154
		FY 01 BES	259.577	246.023	193.000	194.834	187.767	164.354	147.954
		Delta	**-5.865**	**0.000**	**-40.198**	**-37.700**	**-60.000**	**-95.000**	**-110.200**
63747E	ELECTRIC VEHICLES	FY 00 PB	9.000	0.000	0.000	0.000	0.000	0.000	0.000
		FY 01 BES	9.000	0.000	0.000	0.000	0.000	0.000	0.000
		Delta	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
63760E	COMMAND, CONT'L & COMMUNICATION SYS	FY 00 PB	177.492	222.888	213.380	210.483	199.480	219.046	218.671
		FY 01 BES	169.370	222.888	140.380	127.483	138.480	149.046	155.671
		Delta	**-8.122**	**0.000**	**-73.000**	**-83.000**	**-61.000**	**-70.000**	**-63.000**
63761E	COMMUNICATION & SIMULATION TECH	FY 00 PB	52.258	0.000	0.000	0.000	0.000	0.000	0.000
		FY 01 BES	49.988	0.000	0.000	0.000	0.000	0.000	0.000
		Delta	**-2.270**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
63762E	SENSOR & GUIDANCE TECHNOLOGY	FY 00 PB	209.971	232.319	211.893	236.586	251.482	242.096	251.896
		FY 01 BES	204.682	232.319	189.002	226.086	251.482	249.096	276.896
		Delta	**-5.289**	**0.000**	**-22.891**	**-10.500**	**0.000**	**7.000**	**25.000**
63763E	MARINE TECHNOLOGY	FY 00 PB	23.659	22.538	21.964	48.396	55.896	57.696	60.496
		FY 01 BES	24.779	22.538	34.964	48.396	55.896	55.696	60.496
		Delta	**1.120**	**0.000**	**13.000**	**0.000**	**0.000**	**-2.000**	**0.000**
63764E	LAND WARFARE TECHNOLOGY	FY 00 PB	88.613	97.825	101.376	106.677	77.000	87.000	87.000
		FY 01 BES	85.299	97.825	91.267	92.177	77.000	87.000	87.000
		Delta	**-3.314**	**0.000**	**-10.109**	**-14.500**	**0.000**	**0.000**	**0.000**
63765E	CLASSIFIED	FY 00 PB	50.040	77.780	49.600	19.100	13.100	0.000	0.000
		FY 01 BES	48.797	77.780	97.600	99.800	79.100	65.000	55.000
		Delta	**-1.243**	**0.000**	**48.000**	**80.700**	**66.000**	**65.000**	**55.000**
65114E	BLACKLITE	FY 00 PB	4.985	5.000	5.000	5.000	5.000	5.000	5.000
		FY 01 BES	4.985	5.000	5.000	5.000	5.000	5.000	5.000
		Delta	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE
PE LEVEL SUMMARY COMPARISON OF FY 2000 PRESIDENT'S BUDGET TO FY 2001 BUDGET ESTIMATES SUBMISSION
($ in millions)

PE	TITLE		FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
65502E	SMALL BUSINESS	FY 00 PB	0.000	0.000	0.000	0.000	0.000	0.000	0.000
		FY 01 BES	42.839	0.000	0.000	0.000	0.000	0.000	0.000
		Delta	**42.839**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
65898E	MANAGEMENT HEADQUARTERS (R&D)	FY 00 PB	38.498	31.387	32.632	33.944	35.373	36.634	36.922
		FY 01 BES	32.898	31.387	34.632	35.944	37.373	38.634	38.922
		Delta	**-5.600**	**0.000**	**2.000**	**2.000**	**2.000**	**2.000**	**2.000**
		TOTAL FY 2000 President's Budget	1,930.256	2,002.684	1,883.858	1,938.903	1,978.459	2,021.832	2,066.220
		TOTAL FY 2001 BES	1,904.473	2,002.684	1,883.858	1,938.903	1,978.459	2,021.832	2,066.220
		Delta	**-25.783**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RESEARCH, DEVELOPMENT, TEST AND EVALUATION, DEFENSE-WIDE
PE LEVEL SUMMARY COMPARISON OF FY 2000 PRESIDENT'S BUDGET TO FY 2001 BUDGET ESTIMATES SUBMISSION
($ in millions)

PE	TITLE		FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
	BA-01	FY 00 PB	64.429	64.293	68.792	69.837	75.398	78.259	81.118
		FY 01 BES	61.386	64.293	73.292	84.837	85.398	88.259	81.118
		Delta	**-3.043**	**0.000**	**4.500**	**15.000**	**10.000**	**10.000**	**0.000**
	BA-02	FY 00 PB	945.869	982.967	927.023	953.346	1,012.963	1,030.761	1,056.977
		FY 01 BES	910.873	982.967	1,000.721	996.346	1,030.963	1,098.761	1,138.177
		Delta	**-34.996**	**0.000**	**73.698**	**43.000**	**18.000**	**68.000**	**81.200**
	BA-03	FY 00 PB	876.475	919.037	850.411	876.776	849.725	871.178	886.203
		FY 01 BES	851.492	919.037	770.213	816.776	819.725	791.178	803.003
		Delta	**-24.983**	**0.000**	**-80.198**	**-60.000**	**-30.000**	**-80.000**	**-83.200**
	BA-06	FY 00 PB	43.483	36.387	37.632	38.944	40.373	41.634	41.922
		FY 01 BES	80.722	36.387	39.632	40.944	42.373	43.634	43.922
		Delta	**37.239**	**0.000**	**2.000**	**2.000**	**2.000**	**2.000**	**2.000**
		TOTAL FY 2000 President's Budget	1,930.256	2,002.684	1,883.858	1,938.903	1,978.459	2,021.832	2,066.220
		TOTAL FY 2001 BES	1,904.473	2,002.684	1,883.858	1,938.903	1,978.459	2,021.832	2,066.220
		Delta	**-25.783**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**

Program Element Comparison Summary

Comparison of FY 1999 and 2000 Data:

A comparison of budget data from this R-1 to the February 1999 R-1 supporting the FY 2000 President's Budget submission is submitted in budget exhibit R-1C.

Relationship of FY 2001 Budget Structure to the FY 2000 Budget approved by Congress:

Budget Activity 2

PE 0602301E, Computing Systems and Communications Technology, Project ST-28

DARPA established Project ST-28, Asymmetric Threat, as part of the May 1999 POM submission. The project will explore new levels of automation technologies to develop the capability to detect a small, loosely organized group as they plan and execute an unconventional attack. Efforts will focus on technologies to automatically recognize and identify humans at a distance; to automatically discover, extract, and link together sparse evidence of a group's intentions from vast amounts of information; to study beliefs and behaviors of small groups for simulating and wargaming these new opponents in the asymmetric world; and improve decision aids for distributed teams of analysts in dynamic situations.

PE 0602302E Extensible Information Systems, Project AE-04

DARPA established Project AE-04, Gigabyte Applications, subsequent to the FY 2000 President's submission. The project will target breakthroughs in DoD-focused gigabyte applications to enable robust operation of DoD's mission-critical systems including geographically dispersed platforms that are dependent on extremely high data flows. The efforts will leverage advances made in earlier programs for high-speed communications and networking, including, but not limited to, the Next Generation Internet program.

PE 0602383E, Biological Warfare Defense

In accordance with PDM direction of August 16, 1999, DARPA increased FY 2001 genetic sequencing of biological warfare agents by $9.9 million to continue the sequencing of high-threat known and potential biowarfare agents. The increase was offset with funding from programs other than chemical or biological programs. Overall, DARPA's Biological Warfare Defense program has been increased across the FYDP in recognition of the need to counter the critical BW threat.

Research, Development Test and Evaluation, Defensewide
Defense Advanced Research Projects Agency
Fiscal Guidance Track
(Dollars in Millions)

	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005
POM Fiscal Guidance	1,883.858	1,938.903	1,978.459	2,021.832	2,066.220
PDM I Adjustments	0.000	0.000	0.000	0.000	0.000
Functional Transfers	0.000	0.000	0.000	0.000	0.000
Other	0.000	0.000	0.000	0.000	0.000
Budget Estimates Submission	1,883.858	1,938.903	1,978.459	2,021.832	2,066.220

Research, Development Test and Evaluation, Defensewide
Defense Advanced Research Projects Agency
Program and Financing
(Dollars in Thousands)

			Budget Plan	
Identification code: 97-0400-DE		Estimate FY 1999	Estimate FY 2000	Estimate FY 2001
Program by activities:				
	Direct Program:			
01.000	Basic Research	61,386	64,293	73,292
02.000	Applied Research	910,873	982,967	1,000,721
03.000	Advanced Technology Development	851,492	919,037	770,213
06.000	Management Support	80,722	36,387	39,632
	Total Direct Program	1,904,473	2,002,684	1,883,858
R01.000	Reimbursable Program:	27,000	25,000	25,000
	Total Program	1,931,473	2,027,684	1,908,858
	Financing:			
F11.010	New Federal Funds (-)	-27,000	-25,000	-25,000
	Total Budget Authority	1,904,473	2,002,684	1,883,858
	Budget authority:			
F40.010	Appropriation EN/EST	1,939,914	2,002,684	1,883,858
F40.730	Reduction pursuant to PL 105-262, Section 8034	-3,929		
F40.733	Reduction pursuant to PL 105-262, Section 8108	-5,729		
F41.000	Transferred to Other Accounts	-25,783		
	Total Budget Authority	1,904,473	2,002,684	1,883,858

Research, Development Test and Evaluation, Defensewide
Defense Advanced Research Projects Agency
Program and Financing
(Dollars in Thousands)

			Budget Plan
Identification code: 97-0400-DE			Estimate FY 1999
Program by activities:			
	Direct Program:		
01.000		Basic Research	61,386
02.000		Applied Research	910,873
03.000		Advanced Technology Development	851,492
06.000		Management Support	80,722
		Total Direct Program	1,904,473
R01.000	Reimbursable Program:		27,000
		Total Program	1,931,473
	Financing:		
F14.010		New Non-Federal Sources	
F11.010		New Federal Funds (-)	-27,000
		Total Budget Authority	1,904,473
	Budget authority:		
F40.010		Appropriation EN/EST	1,939,914
F40.730		Reduction pursuant to PL 105-262, Section 8034	-3,929
F40.733		Reduction pursuant to PL 105-262, Section 8108	-5,729
F41.000		Transferred to Other Accounts	-25,783
		Total Budget Authority	1,904,473

Research, Development Test and Evaluation, Defensewide
Defense Advanced Research Projects Agency
Program and Financing
(Dollars in Thousands)

Identification code: 97-0400-DE			Budget Plan Estimate FY 2000
Program by activities:			
	Direct Program:		
01.000		Basic Research	64,293
02.000		Applied Research	982,967
03.000		Advanced Technology Development	919,037
06.000		Management Support	36,387
		Total Direct Program	2,002,684
R01.000	Reimbursable Program:		25,000
		Total Program	2,027,684
	Financing:		
F11.010		New Federal Funds (-)	-25,000
		Total Budget Authority	2,002,684
	Budget authority:		
F40.010		Appropriation EN/EST	2,002,684
		Total Budget Authority	2,002,684

Research, Development Test and Evaluation, Defensewide
Defense Advanced Research Projects Agency
Program and Financing
(Dollars in Thousands)

Identification code: 97-0400-DE			Budget Plan Estimate FY 2001
Program by activities:			
	Direct Program:		
01.000		Basic Research	73,292
02.000		Applied Research	1,000,721
03.000		Advanced Technology Development	770,213
06.000		Management Support	39,632
		Total Direct Program	1,883,858
R01.000	Reimbursable Program:		25,000
		Total Program	1,908,858
	Financing:		
F11.010		New Federal Funds (-)	-25,000
		Total Budget Authority	1,883,858
	Budget authority:		
F40.010		Appropriation EN/EST	1,883,858
		Total Budget Authority	1,883,858

Research, Development Test and Evaluation, Defensewide
Defense Advanced Research Projects Agency
Program and Financing
(Dollars in Thousands)

Code	Identification code: 97-0400-DE	Obligation Plan Estimate FY 1999	Estimate FY 2000	Estimate FY 2001
	Program by activities:			
	Direct Program:			
01.000	Basic Research	53,061	63,857	71,942
02.000	Applied Research	839,672	972,153	998,058
03.000	Advanced Technology Development	845,888	908,905	792,537
06.000	Management Support	86,745	43,037	39,145
	Total Direct Obligations	1,825,366	1,987,952	1,901,682
R01.000	Reimbursable Obligations	27,120	25,000	25,000
	Total Obligations	1,852,486	2,012,952	1,926,682
	Financing:			
	Offsetting collections from:			
F11.010	New Federal Funds (-)	-27,120	-25,000	-25,000
	Unobligated balance available, start of year:			
F21.020	For completion of prior year budget plans	-206,564	-285,671	-300,403
	Unobligated balance available, end of year:			
F24.020	For completion of prior year budget plans	285,671	300,403	282,579
	Total Budget Authority	1,904,473	2,002,684	1,883,858
	Budget Authority:			
F40.010	Appropriation EN/EST	1,939,914	2,002,684	1,883,858
F40.730	Reduction pursuant to PL 105-262, Section 8034	-3,929		
F40.733	Reduction pursuant to PL 105-262, Section 8108	-5,729		
F41.000	Transferred to Other Accounts	-25,783		
	Total Budget Authority	1,904,473	2,002,684	1,883,858

Research, Development Test and Evaluation, Defensewide
Defense Advanced Research Projects Agency
Program and Financing
(Dollars in Thousands)

		Obligations
Identification code: 97-0400-DE		Fiscal Year 1998 Funds FY 1999 Estimate
Program by activities:		
Direct Program:		
01.000	Basic Research	883
02.000	Applied Research	65,430
03.000	Advanced Technology Development	122,120
06.000	Management Support	18,131
	Total Direct Obligations	206,564
R01.000	Reimbursable Obligations	120
	Total Obligations	206,684
Financing:		
	Offsetting collections from:	
F11.010	New Federal Funds	-120
	Unobligated balance available, start of year:	
F21.020	For completion of prior year budget plans	-206,564
F21.910	Reprogramming from/to prior year budget plans	37
	Total Budget Authority	37
F42.000	Transferred from other accounts	37
	Total Budget Authority	37

Research, Development Test and Evaluation, Defensewide
Defense Advanced Research Projects Agency
Program and Financing
(Dollars in Thousands)

Identification code: 97-0400-DE		Obligations: Fiscal Year 1999 Funds FY 1999 Estimate	Obligations: Fiscal Year 1999 Funds FY 2000 Estimate
Program by activities:			
Direct Program:			
01.000	Basic Research	52,178	9,208
02.000	Applied Research	774,242	136,631
03.000	Advanced Technology Development	723,768	127,724
06.000	Management Support	68,614	12,108
	Total Direct Obligations	1,618,802	285,671
R01.000	Reimbursable Obligations	27,000	
	Total Obligations	1,645,802	285,671
Financing:			
	Offsetting collections from:		
F11.010	New Federal Funds	-27,000	
	Unobligated balance available, start of year:		
F21.020	For completion of prior year budget plans		-285,671
	Unobligated balance available, end of year:		
F24.020	For completion of prior year budget plans	285,671	
	Total Budget Authority	1,904,473	0
F40.010	Appropriation EN/EST	1,939,914	
F40.730	Reduction pursuant to PL 105-262, Section 8034	-3,929	
F40.733	Reduction pursuant to PL 105-262, Section 8108	-5,729	
F41.000	Transferred to Other Accounts	-25,783	
	Total Budget Authority	1,904,473	

Research, Development Test and Evaluation, Defensewide
Defense Advanced Research Projects Agency
Program and Financing
(Dollars in Thousands)

Identification code: 97-0400-DE		Obligations: Fiscal Year 2000 Funds FY 2000 Estimate	FY 2001 Estimate
Program by activities:			
Direct Program:			
01.000	Basic Research	54,649	9,644
02.000	Applied Research	835,522	147,445
03.000	Advanced Technology Development	781,181	137,856
06.000	Management Support	30,929	5,458
	Total Direct Obligations	1,702,281	300,403
R01.000	Reimbursable Obligations	25,000	
	Total Obligations	1,727,281	300,403
Financing:			
	Offsetting collections from:		
F11.010	New Federal Funds	-25,000	
	Unobligated balance available, start of year:		
F21.020	For completion of prior year budget plans		-300,403
	Unobligated balance available, end of year:		
F24.020	For completion of prior year budget plans	300,403	
	Total Budget Authority	2,002,684	0
F40.010	Appropriation EN/EST	2,002,684	
	Total Budget Authority	2,002,684	

Research, Development Test and Evaluation, Defensewide
Defense Advanced Research Projects Agency
Program and Financing
(Dollars in Thousands)

		Obligations	
		Fiscal Year 2001 Funds	
Identification code: 97-0400-DE		FY 2001 Estimate	FY 2002 Estimate
Program by activities:			
Direct Program:			
01.000	Basic Research	62,298	10,994
02.000	Applied Research	850,613	150,108
03.000	Advanced Technology Development	654,681	115,532
06.000	Management Support	33,687	5,945
	Total Direct Obligations	1,601,279	282,579
R01.000	Reimbursable Obligations	25,000	
	Total Obligations	1,626,279	282,579
Financing:			
	Offsetting collections from:		
F11.010	New Federal Funds	-25,000	
	Unobligated balance available, start of year:		
F21.020	For completion of prior year budget plans		-282,579
	Unobligated balance available, end of year:		
F24.020	For completion of prior year budget plans	282,579	
	Total Budget Authority	1,883,858	0
F40.010	Appropriation EN/EST	1,883,858	
	Total Budget Authority	1,883,858	

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
FY 2001 BUDGET ESTIMATES SUBMISSION
SCHEDULE OF CIVILIAN AND MILITARY PERSONNEL

	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	FY 2006
I. CIVILIAN PERSONNEL (Full-time Equivalents (FTE))								
RDT&E Defensewide								
US Direct Hire	138	160	159	159	159	159	159	159
Total, RDT&E	138	160	159	159	159	159	159	159
II. ACTIVE MILITARY PERSONNEL (ES)								
Officer, Army	3	3	3	3	3	3	3	3
Officer, Navy	3	3	3	3	3	3	3	3
Officer, Air Force	12	12	12	12	12	12	12	12
Total Military	18	18	18	18	18	18	18	18
TOTAL	156	178	177	177	177	177	177	177

Exhibit PB-4 Schedule of Civilian and Military Personnel

SECTION II

MODERNIZATION AND INVESTMENT

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research				R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E					
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	61.386	64.293	73.292	84.837	85.398	88.259	81.118	Continuing	Continuing
Information Sciences CCS-02	16.201	18.892	20.953	30.700	30.700	30.700	30.700	Continuing	Continuing
Electronic Sciences ES-01	19.662	23.124	18.339	20.084	23.645	32.506	36.365	Continuing	Continuing
Materials Sciences MS-01	25.523	22.277	34.000	34.053	31.053	25.053	14.053	Continuing	Continuing

(U) Mission Description:

(U) The Defense Research Sciences Program Element is budgeted in the Basic Research Budget Activity because it provides the technical foundation for long-term improvements through the discovery of new phenomena and the exploration of the potential of such phenomena for national security applications. It supports the scientific study and experimentation that is the basis for more advanced knowledge and understanding in information, electronic and materials sciences.

(U) The Information Sciences project supports basic scientific study and experimentation in information sciences technology areas such as computational models, biological computing and optical processes. This project is also exploring innovative approaches to the composition of software and novel human computer interface technologies.

(U) The Electronic Sciences project explores and demonstrates electronic and optoelectronic devices, circuits and processing concepts that will provide: (1) new technical options for meeting the information gathering, transmission and processing required to maintain near-real time knowledge of the enemy and the ability to communicate decisions based on that knowledge to all forces in near-real time; and (2) a substantial increase in performance and cost reduction of military systems providing these capabilities.

(U) The Materials Sciences project is concerned with the development of: high power density/high energy density mobile and portable power sources; processing and design approaches for nanoscale and/or biomolecular materials and interfaces; medical pathogen countermeasures; materials and measurements for molecular-scale electronics; advanced thermoelectric materials for cooling and power generation; spin-dependent materials and devices; and novel propulsion concepts.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E

(U) Program Change Summary: (*In Millions*)	FY1999	FY 2000	FY 2001
Previous President's Budget	64.429	64.293	68.792
Current Budget	61.386	64.293	73.292

(U) **Change Summary Explanation:**

FY 1999 Decrease reflects SBIR reprogramming and minor realignment of program priorities.

FY 2001 Increase reflects expansion of molecular electronics, nanoscale/biomolecular materials and spin-dependent materials and devices efforts in Project MS-01.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research					R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Information Sciences CCS-02	16.201	18.892	20.953	30.700	30.700	30.700	30.700	Continuing	Continuing

(U) **Mission Description:**

(U) This project supports scientific study and experimentation that is the basis for more advanced knowledge and understanding in information sciences technology areas related to long-term national security requirements such as computational models and new mechanisms for performing computation and communication involving biological and optical processes. This project is also exploring innovative approaches to the composition of software and novel human computer interface technologies.

(U) In the area of biological computing, the project will support the scientific study and experimentation that is at the interface of information technology and biological technology, with emphasis on biological software, computation based on biological materials, physical interfaces between electronics and biology, and interactive biology. It will also apply information technology to accelerate the analysis and synthesis of biological processes. The seamless integration of information technology and biological processes will provide the ability to exert computational control over biological and chemical processes.

(U) In the area of optical communication and computing, the project will explore new approaches to transmission based on solitons (plasma waves) and identify novel buffering technologies that can be substituted for optical delay lines.

(U) In the area of human computer interfaces, the project will study information management, interface technologies and their relationship to cognitive processes.

(U) Information Technology Expeditions will explore information technologies that are not in the domain of traditional information sciences, for example: creation of a new programming language suitable for teaching computer users, without previous programming experience; the fabrication of inorganic semiconductor transistors and logic units by printing; development of handheld communication and computer devices that users can interact with through speech and vision cueing without using standard keyboard entry.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Biological Computing. ($ 6.730 Million)
  - Demonstrated and validated computing models, with emphasis on DNA-based logic operations and cell-based computation.
  - Investigated novel control mechanisms for self-organizing and autonomous systems.

- Human Computer Interfaces. ($ 9.471 Million)
  - Demonstrated human-computer interaction for crisis planning.
  - Investigated feedback-driven approaches to information management.
  - Validated low-power configurable architecture; developed supporting software; and demonstrated automated mapping of 500K elements.

(U) **FY 2000 Plans:**

- Biological and Information Sciences. ($ 10.892 Million)
  - Evaluate alternative approaches to DNA-based computing and identify the most promising research opportunities for enhancement and acceleration.
  - Explore mechanisms for sequencing of DNA-based computations.
  - Investigate novel approaches to real-time biological instrumentation in support of interactive biology, including development of minimally invasive imaging tools for monitoring the state of ongoing biological experiments.

- Amorphous and Optical Computing. ($ 3.000 Million)
  - Identify alternative optical buffering technologies.
  - Investigate the use of game theory, probabilistic methods, and amorphous computing in Information Technology (IT), for use in decision aids and time critical systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

- Human Computer Interfaces and Information Technology Expeditions. ($ 5.000 Million)
  - Design and implement a prototype interactive programming language.
  - Create a prototype Information Grid Room (IGR) that can provide invisible computing and data storage for a single user.

(U) **FY 2001 Plans:**

- Biological and Information Sciences. ($ 10.000 Million)
  - Prototype demonstration of robot controlled sequencing of DNA-based computations.
  - Demonstrate real-time multi-sensor imaging of cell processes in support of interactive biology.
  - Establish focused research initiatives at the interface between biology, engineering, and information sciences.
  - Demonstrate use of high resolution imaging technology and signal transduction to effect interactive control over simple biological systems.

- Amorphous and Optical Computing. ($ 2.953 Million)
  - Laboratory demonstration of soliton-based packet multiplexing, incorporating optical buffering.
  - Evaluate alternative approaches to the implementation of game theory, probabilistic methods, amorphous computing in decision tools and software development.

- Information Technology Expeditions. ($ 8.000 Million)
  - Design a universal software controlled communication interface that adapts to changes in the network and the surrounding environment.
  - Define the architecture for the development of a wireless handheld computer that enables users to interact through speech and video.
  - Upgrade IGR to support two users in distributed sites.
  - Develop laser patterned source-drain structures for printed transistors.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project CCS-02

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research					R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Electronic Sciences ES-01	19.662	23.124	18.339	20.084	23.645	32.506	36.365	Continuing	Continuing

(U) **Mission Description:**

(U) This project seeks to continue the phenomenal progress in microelectronics innovation that has characterized the last decades by exploring and demonstrating electronic and optoelectronic devices, circuits and processing concepts that will: 1) provide new technical options for meeting the information gathering, transmission and processing required to maintain near real-time knowledge of the enemy and the ability to communicate decisions based on that knowledge to all forces in near real-time; and 2) provide new means for achieving substantial increases in performance and cost reduction of military systems providing these capabilities. Research areas include new electronic and optoelectronic device and circuit concepts, operation of devices at higher frequency and lower power, extension of diode laser operation to new wavelength ranges relevant to military missions, development of uncooled and novel infrared detector materials for night vision and other sensor applications, development of innovative optical and electronic technologies for interconnecting modules in high performance systems, research to realize field portable electronics with reduced power requirements and research addressing affordability and reliability. Additionally, electronically controlled microinstruments offer the possibility of nanometer-scale probing, sensing and manipulation for ultra-high density information storage "on-a-chip", for nanometer-scale patterning, and for molecular level analysis and synthesis. These microinstruments for nanometer-scale mechanical, electrical and fluidic analysis offer new approaches to integration, testing, controlling, manipulating and manufacturing nanometer-scale structures, molecules and devices.

(U) This project is also concerned with coupling university based engineering research centers of excellence with appropriate industry groups to conduct research leading to development of advanced optoelectronic components critical to enhancing the effectiveness of military platforms that enable warfighter capabilities for comprehensive awareness and precision engagement, and contribute to the continued advancement of Next Generation Internet capabilities. Topics to be researched include emitters, detectors, modulators and switches operating from infrared to ultra violet wavelengths, and related heterogeneous materials processing and device fabrication technologies for realizing compact, integrated optoelectronic modules.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Infrared Detector Materials. ($ 2.861 Million)
  - Established feasibility of new uncooled detector structures, including micro-machined arrays, thin film ferroelectrics and bolometric materials.
- UltraElectronics. ($ 4.641 Million)
  - Demonstrated programmable matched filter operating at gigahertz speed with substantially less power than silicon complimentary metal oxide semiconductor (Si CMOS), completely integrated molecular beam epitaxy (MBE) growth system that realized closed-loop control of atomic layer growth and quantum device structures.
- UltraPhotonics. ($ 7.179 Million)
  - Identified the device properties limiting performance of vertical cavity lasers and demonstrated methods for controlling their output beam quality.
- Electro-Magnetic Interference Electronics. ($ 1.928 Million)
  - Integrated promising new elements of ultraelectronics, high power electronics, non-volatile memory and Electro-Magnetic Interference (EMI) electronics. Addressed, evaluated and applied current EMI thrusts in smaller, lighter, more mobile information systems and highest performance components and systems.
- Mechanical Electronics. ($ 0.954 Million)
  - Initiated mechanical electronics development resulting in very high efficiency, low voltage Direct Current to Direct Current (DC-DC) converters.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

- Terahertz Technology. ($ 2.099 Million)
  - Explored technologies for a region of the electromagnetic spectrum (300 Ghz to 10 Thz, 1 mm to 30 micrometer) that has previously been difficult to access using conventional technologies, in order to exploit opportunities in environmental sensing, upper-atmosphere imagery and covert satellite communications.

(U) **FY 2000 Plans:**

- Mechanical Electronics. ($ 1.898 Million)
  - Demonstrate the properties for mechanical switches that include device speed and current density scale and size, hysteretic behavior for non-volatile memory applications and reduction of threshold switching voltage to below 10V.

- Terahertz Technology. ($ 3.416 Million)
  - Continue to exploit the terahertz region of the electromagnetic spectrum by investigating the best semiconductor approaches to sources and detectors, identifying mission critical operation and investigate the feasibility of integrating these components to form a range of compact subsystems for applications in space based communications, remote sensing, covert communications, and chem-bio detection.

- Microinstruments. ($ 11.810 Million)
  - Research new technology for diagnostic instruments to support, maintain and service the warfighter and military platforms. Investigate new technology concepts that support high volume/low cost wearable and hand-held diagnostic instruments. Microinstruments "on-a-chip" concepts that integrate sensors, electronics, storage, display and actuation are the goals of this research. Microinstruments that include fluid dispensing and fluid sensing and fluid identification are important for "in-the-field" medical, chemical/biological and equipment diagnostics and repair.

- University Opto-Centers. ($ 6.000 Million)
  - Establish university opto-centers that are focused on creating new capabilities for the design, fabrication and demonstration of chip-scale modules which integrate photonic, electronic and MEMS based technologies. Identify university technology research goals and modality for facilitating access by industry to these technologies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project ES-01

(U) **FY 2001 Plans:**

- Terahertz Technology. ($ 3.800 Million)
  - Demonstrate, for the terahertz spectral region, the best semiconductor quantum-well approaches to sources, demonstrate semiconductor quantum-well detectors and identify system requirements to achieve space communications, upper-atmosphere imagery and close-operations covert communications.

- Microinstruments. ($ 2.539 Million)
  - Demonstrate a patterning microinstrument that writes a pattern of array of 50nm minimum - feature-size (MFS) bits or pixels at a rate of $6cm^2$/sec over an area of $1cm^2$. Demonstrate fluidic patterning of pixels 20nm x 20nm over a 1mm x 1mm area using a microinstrument "on-a-chip". Demonstrate an array of 10,000 probes for imaging 10nm defects, electrical pads or bits on an integrated circuit. Demonstrate non-destructive controlled manipulation of cells.

- University Opto-Centers. ($ 12.000 Million)
  - Demonstrate initial chip-scale integrated photonic, electronic and microelectromechanical systems (MEMS) modules. Identify most compelling module DoD applications and measure level of industry commitment to adopt chip-scale integration approach.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost To Complete	Total Cost
Materials Sciences MS-01	25.523	22.277	34.000	34.053	31.053	25.053	14.053	Continuing	Continuing

(U) **Mission Description:**

(U) This project is concerned with fundamental research leading to the development of high power density/high energy density mobile and portable power sources; advanced thermoelectric materials for cooling and power generation; processing and design approaches for nanoscale and/or biomolecular materials and interfaces; materials and measurements for molecular-scale electronics; a new class of semiconductor electronics based on the spin degree of freedom of the electron, in addition to (or in place of) the charge; medical pathogen countermeasures; and novel methods for reducing drag in future generations of high-speed ships.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Portable Power. ($ 9.395 Million)
  - Optimized catalysts, membranes and separator plates for high energy density solid oxide and direct methanol fuel cells.
  - Conducted brassboard testing of compact, high performance 500W solid oxide fuel cells for portable power applications.
  - Demonstrated novel 500W thermophotovoltaic power sources based on advanced materials.

- Nanoscale/Biomolecular Materials. ($ 6.306 Million)
  - Demonstrated the applicability of nanostructural materials in defense applications such as armor, high strength fibers, coatings or electronics.
  - Explored novel concepts in biomolecular materials and interfaces.
  - Developed single molecules and/or nanoparticles that exhibit electronic functionality and measured their intrinsic electronic properties.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

- Pathogen Countermeasures. ($ 5.198 Million)
  - Determined mechanisms of disease causing (virulence) factors in pathogens of concern to the DoD.

- Thermoelectric Materials. ($ 3.712 Million)
  - Developed thin film cooler utilizing quantum well structures.

- Advanced Drag Reduction (Fast Ship). ($ 0.912 Million)
  - Conducted study to assess military utility and top-level system implications of high-speed heavy lift for future forces.
  - Conducted study to identify and assess different possible approaches for hydrodynamic drag reduction.

(U) **FY 2000 Plans:**

- Portable Power. ($ 5.000 Million)
  - Design, build and test portable power systems that operate directly on logistics fuels.
  - Demonstrate an integrated 50W proton exchange membrane fuel cell operating on several novel hydrogen sources.
  - Demonstrate a portable, packaged direct methanol fuel cell.

- Nanoscale/Biomolecular Materials. ($ 7.167 Million)
  - Explore novel processing schemes for the formation of nanoscale/biomolecular and spin-dependent materials, interfaces, and devices.
  - Explore the capabilities of quasicrystals, carbon nanotubes, quantum dots, and other nanostructured/biomolecular materials for enhancing the structural and functional performance of defense systems.

- Molecular Electronics. ($ 7.110 Million)
  - Demonstrate that two interconnected molecules and/or nanoparticles show the anticipated functionality.
  - Demonstrate the ability to reversibly and repeatably transfer information from one molecule or nanoparticle to another.
  - Demonstrate that molecular and/or nanostructured materials can perform a storage function that can be driven from one state to another by an external signal.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

- Advanced Drag Reduction (Fast Ship). ($ 3.000 Million)
  - Conduct model-based assessment of drag reduction alternatives; develop a family of minimum-drag ship designs for different size and speed regimes, which balance hull shaping, lift generation, and friction drag reduction considerations.
  - Commence laboratory-scale confirmation testing of predictions arising from model-based assessments.

(U) **FY 2001 Plans:**

- Nanoscale/Biomolecular Materials. ($ 10.000 Million)
  - Demonstrate enhanced performance from materials and processes incorporating nanostructured components.
  - Demonstrate the use of quantum chemistry for the theoretical design of new nanoscale/biomolecular/multifunctional materials and structures.
  - Explore the interface between biological systems and abiotic surfaces.

- Spin-Dependent Materials and Devices. ($ 7.000 Million)
  - Demonstrate spin-polarized transport across ferromagnetic/semiconductor interfaces.
  - Optimize spin lifetime in semiconductor structures.

- Molecular Electronics. ($ 13.000 Million)
  - Demonstrate that molecules and/or nanoparticles can self-assemble into functional, regular patterns forming a molecular memory.
  - Demonstrate assembly architectures that enable interconnected molecules and/or nanostructures to function even though some of the molecular components are defective.
  - Build and test a minimum 16-bit functional, reversible molecular memory sub-unit.

- Advanced Drag Reduction (Fast Ship). ($ 4.000 Million)
  - Complete laboratory-scale confirmation testing of predictions arising from model-based assessments.
  - Develop scale model testbed of balanced minimum-drag ship design.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA1 Basic Research	R-1 ITEM NOMENCLATURE Defense Research Sciences PE 0601101E, Project MS-01

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Next Generation Internet PE 0602110E				
COST *(In Millions)*	FY1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	42.430	40.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Next Generation Internet NGI-01	42.430	40.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The Next Generation Internet (NGI) initiative has three goals: (1) promote experimentation with the next generation of networking technologies; (2) connect universities and national laboratories with high speed networks that are 100 - 1000 times faster than today's Internet; and (3) demonstrate revolutionary applications that meet important national goals and missions. The principal agencies involved in this initiative are DARPA, NSF, NIST, NIH and NASA. These agencies will share in funding this research and development effort. The DARPA activity will be aimed at part of the first two goals. DARPA will demonstrate end-to-end network connectivity at 1+ gigabits-per-second for 10 or more NGI sites. The network technologies to be addressed include multi-gigabit broadband networks, guaranteed quality of service mechanisms, and integrated network management. These technologies will be demonstrated in an NGI developed testbed environment. Defense-specific application of NGI-developed technology is funded in the Extensible Information Systems program element (0602302E).

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Gigabit-per-second Network Connectivity. ($ 27.530 Million)
  - Implemented 10 gigabit-per-second, multi-wave optically switched Wavelength Division Multiplexed (WDM) technology in NGI testbed.
  - Implemented an alpha-level prototype high-speed optical multiplexor and develop specification of Internet Protocol (IP)/WDM protocol structure.
  - Implemented prototype components of network monitoring and management system.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Next Generation Internet PE 0602110E

- Network Management. ($ 14.900 Million)
  - Defined application program interfaces for information management and collaborative applications.
  - Executed regional partnerships for revolutionary applications.

(U) **FY 2000 Plans:**

- Gigabit-per-second Network Connectivity. ($ 17.000 Million)
  - Implement variable rate access technologies and prototype of distributed optical switching capability compatible with 100 Gb/s optical network.
  - Implement streamlined Internet over WDM protocol structure, eliminating two layers of existing telecommunications infrastructure.

- Network Management. ($ 23.000 Million)
  - Develop network planning and simulation technology to meet requirements for NGI scale networks.
  - Demonstrate real-time (500-msec response) monitoring and control of network resources at all levels.
  - Complete interconnection of Supernet testbed components and software with 2.5 gigabit-per-second access architecture, up to 10 gigabit-per-second backbone, and 100 Gb/s distributed switching capacity.
  - Demonstrate information management and collaborative applications operating over NGI testbed.

(U) **FY 2001 Plans:**

- Not Applicable.

(U) **Program Change Summary:** (*In Millions*)	**FY1999**	**FY 2000**	**FY 2001**
Previous President's Budget	49.504	40.000	0.000
Current Budget	42.430	40.000	0.000

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Next Generation Internet PE 0602110E

(U) **Change Summary Explanation:**

FY 1999 Decrease reflects SBIR reprogramming and $5.000 Million transfer to OSD HPC Modernization program element (0603755D) for the partnership between centers program.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	314.100	322.874	356.523	318.231	334.374	341.948	348.277	Continuing	Continuing
JASON ST-01	1.188	1.200	1.200	1.200	1.200	1.200	1.200	Continuing	Continuing
Intelligent Systems and Software ST-11	85.512	77.018	90.200	75.100	62.536	74.393	68.034	Continuing	Continuing
High Performance and Global Scale Systems ST-19	154.631	159.900	125.623	83.931	107.838	117.055	129.743	Continuing	Continuing
Software Engineering Technology ST-22	16.345	17.227	18.100	18.700	19.300	19.300	19.300	Continuing	Continuing
Information Survivability ST-24	56.424	67.529	88.400	99.800	107.800	106.500	110.000	Continuing	Continuing
Asymmetric Threat ST-28	0.000	0.000	33.000	39.500	35.700	23.500	20.000	Continuing	Continuing

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because it funds projects directed toward the application of advanced, innovative computing systems and communications technologies.

(U) The JASONs project consists of an independent group of distinguished scientists and technical researchers that provide analysis of critical national security issues.

(U) The efforts funded in the Intelligent Systems and Software project focus on the development of new information processing technology concepts that lead to fundamentally new software and intelligent system capabilities. This will enable advanced information systems to more effectively accomplish decision-making tasks in stressful, time sensitive situations and create efficient software intensive defense systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E

(U) The High Performance and Global Scale Systems project develops the computing, networking, and associated software technology base underlying the solutions to computational and information-intensive applications for future defense and federal needs. These technologies will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software technologies, advanced mobile information technology and prototype experimental applications critical to defense operations.

(U) The Software Engineering Technology project supports the Software Engineering Institute (SEI) whose mission is to transition state-of-the-art technology, and best practices to improve the acquisition, engineering, fielding, and evolution of software-intensive DoD systems.

(U) The Information Survivability project develops the technology base underlying the solutions to protecting DoD's mission-critical information systems against attack upon or through the supporting infrastructure. These technologies lead to generations of stronger protection, higher performance, and more cost-effective security solutions scalable to several thousand sites and to high-performance computing technologies.

(U) The goal of the Asymmetric Threat project is to develop a suite of new technological capabilities to better detect, correlate, and understand asymmetric threats. The four programs in this project are Human Identification at a Distance (HID), Evidence Extraction and Link Discovery (EELD), Wargaming the Asymmetric Threat (WAE), and Genoa.

(U) **Program Change Summary:** (*In Millions*)	**FY1999**	**FY 2000**	**FY 2001**
Previous President's Budget	323.959	322.874	331.023
Current Budget	314.100	322.874	356.523

(U) **Change Summary Explanation:**

FY 1999 Decrease is a result of SBIR reprogramming and minor program repricing.

FY 2001 Increase reflects a reprioritization of agency resources, which resulted in the establishment of a new project, Asymmetric Threat (ST-28) and increased emphasis on information survivability technology in project ST-24.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-01					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
JASON ST-01	1.188	1.200	1.200	1.200	1.200	1.200	1.200	Continuing	Continuing

(U) **Mission Description:**

(U) This project supports the JASONs, an independent group of distinguished scientists and technical researchers that provides analysis of critical national security issues. JASON membership is carefully balanced to provide a wide spectrum of scientific expertise and technical analysis in theoretical and experimental physics, materials, information sciences, and other allied disciplines. The JASON process ensures senior government leaders have the full range of U.S. academic expertise available on issues critical to national security involving classified and unclassified information.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- JASON. ($ 1.188 Million)
  - Continued studies in: counter proliferation of chemical and biological weapons; advanced sensor technologies; advanced computing; land mine detection; battlefield information systems; battlefield planning and control; small unit operations; military communications; and novel materials.

(U) **FY 2000 Plans:**

- JASON. ($ 1.200 Million)
  - Continue studies of interest to DoD in multiple disciplines such as: counter proliferation of chemical and biological weapons; space based radar; small payload space launch systems; advanced computing; multi-layered infrastructure defense; advanced sensor technologies including increased radar noise floor and deep buried target characterization; dispersed land forces technology; battlefield information systems and military communications; ultra low power electronics; fiber lasers; and self-monitoring materials.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-01

(U) **FY 2001 Plans:**

- JASON. ($ 1.200 Million)
  - Continue studies of interest to DoD in multiple disciplines such as: counter proliferation of chemical and biological weapons; advanced space based systems; advanced computing; multi-layered infrastructure defense; advanced sensor technologies; dispersed land forces technology; battlefield information systems and military communications; ultra low power electronics; and advanced signal processing.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Intelligent Systems and Software ST-11	85.512	77.018	90.200	75.100	62.536	74.393	68.034	Continuing	Continuing

(U) **Mission Description:**

(U) This project develops new information processing technology concepts that will lead to fundamentally new software and intelligent systems capabilities. This will enable advanced information systems to more effectively accomplish decision-making tasks in stressful, time sensitive situations and create efficient software-intensive defense systems.

(U) Major areas of technical emphasis are: (a) sensor data processing that leverages software-based intelligent processing to acquire sensory information, including advanced airborne video data; (b) situation analysis that provides for the intelligent integration of information from heterogeneous sources, including advanced airborne video data; interactive problem solving, planning, scheduling and decision analysis; and rapid development of large knowledge bases; (c) situation presentation technologies that provide intelligent interfaces to the resultant information streams, including the integration and application of emerging language understanding and translation to address both Command, Control, Communications, Computing and Intelligence (C4I) community needs; (d) information interoperability technologies to support enhanced effectiveness of multi-national missions; and (e) agent-based software to automatically accept abstract tasking, get needed information and decide how to solve simple problems.

(U) The Human Identification at a Distance (HID) program objective is to develop automated multi-modal surveillance technology for identifying humans at a distance as an enabler for protection and early warning against the Asymmetric Threat. HID redefines and renames the program formerly known as Image Understanding for Force Protection (IUFP) to more fully represent the technologies being explored under this program. HID seeks to improve individual biometric technologies with multiple sensor signatures for multi-range, round-the-clock processing. The goal of this project is to positively identify humans at a distance, at any time day or night, during all weather conditions, with non-cooperative subjects, possibly disguised and alone or in groups. This program is funded in the Asymmetric Threat project (ST-28) beginning in FY 2001.

(U) The DARPA Agent markup Language (DAML) program is developing military software tools for use on InteLink and the emerging C2 Link system. The program's focus is to develop enhanced interoperability technologies that extends the reach of the World Wide Web to include program, sensors, and other data sources, and to enable agent-based programs to use these information sources. DAML will develop a software

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

language that ties the information on a page to machine-readable semantics (ontology), including ontology for InteLink briefings. This effort will provide new technologies for the intelligent integration of information across a wide variety of heterogeneous military sources and systems.

(U) Under the Taskable Agent Software Kit (TASK) program, software agent creation tools will be developed so as to reduce the per-agent development/customization cost for advanced military systems. Software agents are the next generation of software which is able to automatically accept abstract tasking, get needed information, decide how to solve simple problems, help the user solve difficult problems, route useful information and otherwise take action on the user's behalf. This effort will explore mathematical techniques in the areas of Control Theory, Decision Theory, and Operations Research for correctly modeling and analyzing agent environments and the behaviors of agents in these environments. Experiments will reveal the qualitative aspects of environments that favor the use of agent-based systems over object-based systems. Models derived from this program allow the development of rigorous qualitative and quantitative comparisons of agent behaviors with respect to domain and problem features.

(U) As the ST-11 project matures, it will have a reduced emphasis on software composition, i.e., the methodology and tools used to compose intelligent software. Beginning in FY 2000, there will be an increased emphasis on the development of intelligent applications that leverage the composition tools developed in the earlier phase of the project. Specific domains of interest are situation analysis, situation presentation, and the processing of sensor-derived information.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Software Composition. ($ 23.353 Million)
  - Conducted Instrumented Feasibility Demonstration (IFDs) of evolutionary design technologies; IFD participants include USTRANSCOM, Joint STARS, and B2 software maintenance.
  - Investigated active approaches to software composition, with emphasis on aspect-oriented programming; on-the-fly component generation and interconnection; and module self-evaluation and configuration.
  - Demonstrated a 2X reduction in detailed design by integrating Design Web and Computational Tools made for multi-disciplinary optimization.
  - Demonstrated a web-based toolkit of representation, analysis and generation tools.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- Active Sensors. ($ 26.993 Million)
  - Integrated the most successful new image understanding and automatic target recognition technologies into feasibility demonstrations for video image exploitation, synthetic environments, and video surveillance; demonstrated and evaluated impact of embedded image understanding technologies on battlefield awareness.
  - Integrated, demonstrated and evaluated laboratory and airborne systems in simulated military video surveillance missions, and achieved these technology goals: Activity Monitoring - detected soldier incursion and removal of restricted vehicles from a depot; Moving Target Surveillance - maintained track on three removed vehicles and demonstrated reliable target reacquisition as the sensor was multiplexed and tracks were occluded by trees; Precision Video Registration - geolocated moving and stationary vehicles in 80% of the video sequences within 5-10 meters of ground truth.
  - Image Understanding for Force Protection will apply Sensor Technology for automated perimeter security.

- Situation Analysis and Presentation. ($ 35.166 Million)
  - Developed language comprehension technology to provide extraction of content and production of summary information focused on information access, manipulation and creation tasks in order to demonstrate improved readiness for military planning and situation awareness.
  - Developed and demonstrated fully automatic algorithms to determine the structure of radio and TV news broadcasts in several languages allowing military planners and intelligence analysts to detect and track emerging topics.
  - Developed and demonstrated large, integrated situation assessment and course of action knowledge base through reuse of knowledge base components from heterogeneous sources.
  - Defined a million-axiom knowledge base construction problem and competency test for a military challenge problem related to biological weapons requiring technical, military strategy and tactics, and geopolitical knowledge.
  - Demonstrated the utility of man-machine planning and execution control against an aggressive adversary in a realistic simulation of an operational environment and transition to DARPA systems programs as well as to services for further development and integration.
  - Demonstrated and transitioned Intelligent Integration of Information tools and techniques that enabled the rapid construction of large-scale information associates to filter, access, and integrate information from 100s of disparate, heterogenous data sources.
  - Continued Asset Source for Software Engineering Technology (ASSET) program.
  - Explored multi-spectral imaging data reduction techniques.
  - Continued Reuse Technology Adoption Program (RTAP).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

(U) **FY 2000 Plans:**

- Situation Analysis. ($ 27.886 Million)
  - Demonstrate statistically based semantic analysis capabilities.
  - Develop persistent queries for audio and video streams to detect user-defined significant events and to generate alerts.
  - Demonstrate distributed prototype of information-value-based retrieval.
  - Demonstrate scalable implementation of public and secure versions of DIP characterization of network resources.
  - Develop component theory building technologies enabling direct knowledge entry by artificial intelligence novices.
  - Demonstrate language and diagram interface, analogic reasoners, and theory explanation capabilities, as well as, develop 10-20 core theories (5K-10K axioms each).
  - Develop mathematical techniques for modeling and analyzing agent behaviors.

- Situation Presentation and Interaction. ($ 27.149 Million)
  - Specify network-based service architecture Application Program Interface's (API's) for key components of dialogue architecture.
  - Demonstrate usability of dialogue interaction with confirming sub-dialogue to reduce task completion time by 80%, using metrics-based evaluation.
  - Evaluation of dialog for small unit logistics demonstrated in LCS Marine project.
  - Expansion of dialog evaluation beyond the travel scenario with method for cross task comparison.
  - Develop preliminary ontology for InteLink briefings and release initial language design specifications.

- Intelligent Software for Multi-lingual and Coalition Environments. ($ 14.000 Million)
  - Develop a translingual C4I database for use in U.S. and Republic of Korea coalition operations.
  - Field demonstration of automated translation of briefing documents during U.S. exercises in Republic of Korea.
  - Implement TIDES open system architecture version 0.1 providing a web-based environment to support plug in component experiments.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- Intelligent Sensor Processing (Human Identification at a Distance). ($ 7.983 Million)
  - Initiate theoretical studies of candidate biometric features for human identification from a distance.
  - Begin generation of a database containing known biometric feature data for metric-based evaluation of candidate techniques.

(U) **<u>FY 2001 Plans:</u>**

- Situation Analysis. ($ 23.200 Million)
  - Deploy scalable prototype analysis environment in defense application with cross-repository information analysis functionality (semantic retrieval, indexing, value filtering, user defined alerting, and categorizing).
  - Demonstrate secure distributed repository architecture supporting digital objects of arbitrary type.
  - Demonstrate feasibility of combined translingual, multimedia context-based information retrieval.
  - Demonstrate direct knowledge entry by a novice (2K axioms/month) for a military problem.

- Situation Presentation and Interaction. ($ 20.000 Million)
  - Engineering integration of key components of dialogue architecture.
  - Demonstrate and evaluate dialogue performance for Project Marine; complete a complex travel task requiring negotiation twice as fast with automated service support as with the best human assistance.
  - Experiments involving humanitarian assistance/disaster relief/consequence management will be conducted with the Sea Based Battle Lab.
  - Demonstrate interaction of tasks with real-time, web-based, public data.

- Intelligent Software for Multi-lingual and Coalition Environments. ($ 28.000 Million)
  - Extract, translate, and correlate named entities from unstructured documents in multiple languages.
  - Prototype implementation of coalition intelligence integration capability demonstrating synthesis of feedback-based approach to query processing with machine translation.
  - Initial demonstration of summarization in English of foreign language documents using frame semantics.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-11

- DARPA Agent Markup Language (DAML). ($ 10.000 Million)
  - Release working versions of Briefing Tool, Search Tool, and Ontology Creation Tool on Intelink.
  - Define toolset for C2 link application of DAML technologies.
  - Experimental test and refinement of the tool set.

- Taskable Agent Software Kit (TASK). ($ 9.000 Million)
  - Define metrics for analysis of environmental features in military C4I system usage.
  - Perform agent-design method experiments on parametric models of agent interaction systems.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19				

COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
High Performance and Global Scale Systems ST-19	154.631	159.900	125.623	83.931	107.838	117.055	129.743	Continuing	Continuing

(U) **<u>Mission Description</u>:**

(U) This project develops the computing, networking, and associated software technology base underlying the solutions to computational and information-intensive applications for future defense and federal needs. These technologies will lead to successive generations of more secure, higher performance, and more cost-effective microsystems, associated software technologies, advanced mobile information technology and prototype experimental applications critical to defense operations. The project is comprised of the following components:

(U) The Wireless and Global Mobile Information Systems effort will enable mobile wireless users to automatically form ad hoc networks and to exchange a wide range of information both within the ad hoc network and between wireless and fixed networks. This program will develop technologies to: ensure the robust and secure operation of the network, dynamically adapt bandwidth to Radio Frequency (RF) environment, and dynamically reconfigure the network to counter jamming and to provide highest quality-of-service. The program will develop and integrate technologies and techniques at the networking, wireless link/node, and applications levels, enabling access to and utilization of the full range of services available in the Defense Information Infrastructure.

(U) The Networking component develops active networking technologies and associated network management capabilities to support a new paradigm of Internet Protocol (IP) routing and transmission and deeply networked systems. Research is coordinated with DoD, NASA, DoE, NSF, and other federal agencies.

(U) The Data Intensive Systems and Software component develops software and hardware technologies for data-starved applications. This component will develop a new approach to computer memory organization that will eliminate severe bottlenecks in present designs.

(U) The Adaptive Architectures component develops new approaches to the design of computer hardware that incorporates dynamic configuration capabilities. The resultant devices will allow DoD to develop a wide variety of specialized systems by reusing a relatively small set of hardware designs, each of which can be affordably produced in high volumes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

(U) The Systems Environments component develops scalable software which is tailored toward easing the use of systems by application programmers. This includes run-time services, resource allocation, and experimental applications.

(U) The Signal Processing and Electronic Power Management component is developing: 1) software and component level technologies for use in embedded systems that leverage novel signal processing technologies; and 2) innovative power management strategies, both within the chip and at the system level.

(U) A follow-on to Defense Technology Integration efforts budgeted in previous years, the Mobile Code Software program will develop the software technology to resolve time-critical constraints in logistics and mission planning. The resource management problem will be solved via the interaction of light-weight, mobile software components using bottom-up organization approach and negotiation as a technique for resolving ambiguities and conflicts. The technology will enable designers to build systems that operate effectively in highly decentralized environments, making maximum use of local information, providing solutions that are both good enough, and soon enough.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Global Mobile Information Systems. ($ 15.626 Million)
  - Demonstrated application support including automatic file and data base replication and distribution for distributed computing in mobile environments.
  - Demonstrated prototype implementation of integrated high data-rate untethered node.
  - Demonstrated techniques for density and asymmetry adaptation, multicast routing, and dynamic time slot assignment in wireless self-organizing ad hoc networks.
  - Transitioned networking protocol and adaptive link control technologies to DARPA's Small Unit Operations project (PE0603764E) and Radio Application Program Interfaces (APIs) to Joint Tactical Radio System Phase I Architectural Framework.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Networking. ($ 15.172 Million)
  - Extended operation of Active Network testbed to traverse ~10 sites of ~10 switches; each using SmartPackets and composite protocols.
  - Demonstrated active node execution environment supporting resource security, and survivability functions.

- Scalable Systems and Software. ($ 32.250 Million)
  - Released scalable versions of defense-critical engineering software.
  - Demonstrated multiprocessor reduced instruction set computer (RISC) chip (7 issue, 1.6 gigaoperations (GOP), 5-cycle message latency).
  - Investigated instruction set extensions and storage components to allow defense applications to specify whether operations are executed in the central processor or in logic circuits embedded in the memory hierarchy.
  - Conducted system-level design and simulation study of a computation model-based on large amorphous arrays.
  - Established role of Nuclear Magnetic Resonance (NMR) technologies in development of ultrascale computing.

- Adaptive Computing Architectures. ($ 25.169 Million)
  - Debugged and validated novel, configurable component technologies and architectures; demonstrated use of adaptive building blocks in wireless radio applications.
  - Demonstrated 100x user-level software performance improvement over commodity microprocessors on challenge problems; released new algorithm design software environment optimized to leverage adaptive technology.

- Systems Environments. ($ 14.740 Million)
  - Demonstrated experimental scalable structural dynamics application using DARPA sparse matrix library.
  - Demonstrated microfeedback technologies for adaptive services.
  - Released prototype subsystem supporting adaptive resource allocation and consumption in response to changing workload and resource availability.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Signal Processing. ($ 21.467 Million)
  - Published benchmarks for embedded signal processing.
  - Demonstrated enabling technologies including: Discrete Fourier Transform (DFT) chips based on clockless logic, Single Instruction Multiple Datastream (SIMD) and multi-Digital Signal Processing (DSP) board designs, Myricom 2.5 Gbps high speed configurable interconnect.
  - Developed compiler and code generators to permit retargeting of commercial signal processing tools to suit tactical signal processing environments.
  - Evaluated alternative mechanisms for embedded logic and communications subsystems that incorporate biological materials.
  - Investigated techniques, which transduce electrical/optical/magnetic signals to/from chemical and/or biological processes.

- Defense Technology Integration. ($ 30.207 Million)
  - Developed framework for federation of text, image and relational databases.
  - Demonstrated presentation aids for military type documents in English, Korean and a European language.
  - Validated design of secure repository architecture for digital objects up to 100 megabytes in size.
  - Developed Session Management middleware, leveraging multicasting technology that adjusts to variations in bandwidth and connectivity.
  - Developed tools that enable teams and individuals to retrieve situation and task relevant information from static and dynamic archives containing a record of experiences from multi-sensory sources.

(U) **FY 2000 Plans:**

- Global Mobile Information Systems. ($ 13.600 Million)
  - Beta-level prototype of high data-rate untethered nodes incorporating adaptive link controls and frequency agile RF front end with capability to automatically adapt to available spectrum frequencies.
  - Demonstration of self-organizing, self-healing mobile wireless networks supporting Quality of Service (QoS) routing utilizing Internet and Asynchronous Transfer Mode (ATM) networks.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Demonstrate network security techniques, including over the air re-keying, in mobile wireless multihop network.
- Integrate GloMo simulation models and conduct scenario simulations for moderate to large scale mobile wireless networks (100 to 10,000 nodes).

• Networking. ($ 31.815 Million)
- Demonstrate use of active network approach to achieve live protocol updates within two roundtrip times.
- First release of prototype active network toolkits for end-user stations and network elements including performance measurement capabilities.
- Engineering analysis of active network performance.
- Develop new models of traffic and network applicable to varying scales of time and network sizes, which are suitable for predicting network behavior.
- Build a network measurement methodology to support near real-time prediction using modeling and simulation tools.
- Design and demonstrate prototype software for digital amphitheater.

• Data Intensive Systems and Software. ($ 28.665 Million)
- Design processor in memory very large scale integration (VLSI) components that support in situ processing of application data.
- Implement compiler that generates code compatible with processor in memory architecture.
- Simulate data-intensive systems, demonstrating 10-fold performance improvement on critical DoD applications.
- Develop architectural framework for use of data intensive technologies in embedded applications; investigate alternative approaches to package level integration of data intensive technologies with high bandwidth sensor interfaces.

• Adaptive Computing Architectures. ($ 31.739 Million)
- Prototype implementation and runtime libraries supporting adaptive performance monitoring and analysis.
- Demonstrate automated, model-based synthesis of heterogenous Digital Signal Processing (DSP), Application Specific Integrated Circuit/Field Programmable Gate Array (ASIC/FPGA), General Purpose (GP) system designs for large-scale systems.
- Investigate novel approaches to in-situ logic placement and routing.
- Explore and develop highly optimized processing elements and design tools.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Systems Environments. ($ 22.200 Million)
  - Release reference implementation of mission-critical Quality of Service (QoS) architecture.
  - Release prototype operating system with partitioned resource management for strict QoS guarantees.
  - Joint demonstration of QoS management software with Aegis advanced computing testbed; employ Command, Control, Computations, Communications Intelligence Surveillance Reconnaissance (C4ISR) sensor data for targeting with total reallocation latency of less than 5 seconds.

- Signal Processing. ($ 22.881 Million)
  - Implement prototype multiprocessor event collection and analysis system and automated stress test generator for signal processing applications; demonstrate use of high performance signal processing for weapon systems applications.
  - Establish challenge problem testbed for experimental development of 1 cubic foot Synthetic Aperture Radar (SAR)/Automatic Target Recognition (ATR) system.
  - Adapt infrared radar /ATR algorithms for use with adaptive computing systems (ACS) technology and processing of second generation forward looking infrared radar image data; enable 10Hz frame rate and perform joint demonstration with Night Vision Electronics Sensors Directorate.
  - Power Aware Computing and Communication (PAC/C) benchmarks defined and developed.
  - Identify and develop PAC/C experiments with military organizations.

- Mobile Code Software. ($ 9.000 Million)
  - Analyze autonomous software ability to predict, negotiate and track resource requirements under changing environment and time constraints.
  - Develop strategy for the rapid assessment of computation cost of complex sets of constraints.
  - Implement software toolkit for knowbot development, generation and deployment.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

(U) **FY 2001 Plans:**

- Wireless Mobile Information Systems. ($ 13.000 Million)
  - Initiate development of intrusion detection algorithms that affect wireless routing tables.
  - Exploit containment and recovery schemes for compromised wireless nodes.
  - Investigate technologies to optimize RF bandwidth allocation and utilization.
  - Investigate technical approaches for optimizing multimodal wireless networks to provide maximum quality of service.
  - Explore state-of-the-art antennas, receivers, and transmitters for utilizing multiple service providers that employ different frequencies and bandwidths.

- Networking. ($ 28.000 Million)
  - Investigate alternative approaches to large-scale network engineering including simulation technology.
  - Demonstrate performance improvements of 100 percent for large multicast sessions based on active suppression of redundant acknowledgement and retransmission messages.
  - Develop models of network control suitable for on-line parameter tuning, dynamic reconfiguration, fault detection, and for meeting DoD mission critical requirements.
  - Validate modeling and simulation tools, and demonstrate predictive power of the models using measured network data.
  - Test radar image enhancement using coherent processing of signals from multiple radar sources connected by a very high-speed network.
  - Integrate active network capabilities into Run-Time Infrastructure (RTI) for use with high-level architecture (HLA)-compliant simulations; prepare for joint demonstration with Defense Modeling and Simulation Office (DMSO).

- Data Intensive Systems and Software. ($ 24.000 Million)
  - Prototype fabrication of processor in memory very large scale integration (VLSI) components that support in situ processing of application data.
  - Conduct bench experiments to demonstrate that fabricated components achieve performance predicted by simulations.
  - Prototype demonstration of processor in memory (PIM) array.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19

- Adaptive Computing Architectures. ($ 8.623 Million)
  - Release beta version of Adaptive Computing Systems (ACS) software including compilers and support for commercial design environments such as MatLab and Khoros; demonstrate 10x improvement in compilation times.
  - Demonstrate self test diagnosis and reconfiguration to circumvent defective and/or damaged portions of commodity logic components.
  - Develop highly optimized processing elements and integrate into Super Application Specific Integrated Circuit (ASIC) for optimal processing for embedded systems.
  - Develop automated design tools for Super ASIC processors.
  - Investigate alternative approaches to the interfaces and structure of reconfigurable kernels suitable for use in adaptive computing environments.

- Systems Environments. ($ 17.000 Million)
  - Release prototype distributed object software with real-time QoS management.
  - Demonstrate support for mixed workloads of hard, soft, and non-real-time applications.
  - Demonstrate QoS-driven fault detection and recovery within 500 m sec.

- Signal Processing and Electronic Power Management. ($ 22.000 Million)
  - Conduct bench experiments to demonstrate in situ processing of model-based automatic target recognition (ATR) data at 100,000 ray-patch intersections per second.
  - Alpha level prototype of forward-looking sonar towed array with ranging functionality and ability to form 30K independent beams.
  - Demonstration of flight-capable Synthetic Aperture Radar (SAR)/Automatic Target Recognition (ATR) system recognizing 30 target types in presence of camouflage concealment deception.
  - Initial compilation strategies for PAC/C.
  - Demonstrate PAC/C compilation.
  - Simulation of performance/communication real-time tradeoff benefits.
  - Power-aware protocol simulation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-19	

- Mobile Code Software. ($ 13.000 Million)
  - Demonstrate and evaluate software agent's ability to approximate behavior tradeoffs and to utilize negotiation in advanced logistics scenario with a 3-second response requirement.
  - Demonstrate and evaluate software agent's ability for bottom-up organization in advanced logistics scenario with 100-1000 components.
  - Prototype implementation of negotiation technology in real-time scenario with a 500 millisecond response requirement.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-22				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Software Engineering Technology ST-22	16.345	17.227	18.100	18.700	19.300	19.300	19.300	Continuing	Continuing

(U) **Mission Description:**

(U) Software is key to meeting DoD's increasing demand for high quality, affordable, and timely national defense systems. There is a critical need to rapidly transition state-of-the-art technology and best practices to improve the acquisition, engineering, fielding, and evolution of software-intensive DoD systems. This project will fund the technology transition activities of the Software Engineering Institute (SEI) at Carnegie Mellon University. The SEI is a Federally Funded Research and Development Center (FFRDC) sponsored by the Office of the Under Secretary of Defense for Acquisition and Technology. It was established in 1984 as an integral part of the DoD's software initiative to identify, evaluate, and transition high leverage technologies and practices, and to foster disciplined software engineering practices by DoD acquisition and life cycle support programs and within the industrial base where the bulk of defense software is produced. The Institute works across government, industry, and academia to: (1) improve current software engineering activities from both management and engineering perspectives; (2) facilitate rapid, value-added transition of technology into practice; and (3) evaluate and calibrate emerging technologies to determine their potential for improving the evolution of software-intensive DoD systems.

(U) The SEI enables the exploitation of emerging software technology by bringing engineering discipline to software acquisition, development, and evolution. The SEI focuses on software technology areas judged to be of the highest payoff in meeting defense needs. FY 1998 focus areas were: Technical Engineering Practices (including Information Survivability practices, Architecture-centered Software Engineering, and Commercial Off-The-Shelf (COTS)-Based Software Engineering); Enhanced Software Management Capabilities (including release of software measurement handbook and risk evaluation guidebook, Software Process Improvement methods and Capability Maturity Model Integration (CMMI)); and accelerating Adoption of High Payoff Software Technologies.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Software Engineering Technical Practices. ($ 11.100 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-22

- Established/refined guidelines for helping the DoD and DoD contractors migrate legacy systems into product lines. Architecture evaluation guidelines and tradeoff techniques were demonstrated, and an initial version of a security improvement tool kit was developed to help system administrators protect their systems against current and emerging threats. Architecture evaluation techniques for COTS-based systems were offered to reduce costs and risk. Training in the development of COTS-based systems was made available for executives and program managers.

• Software Engineering Management Practices. ($ 3.750 Million)
  - Released the integrated models (software, systems, and Integrated Product and Process Development (IPPD)) under the CMMI framework for public review and pilot test. Published Version 1 of CMMI support products. CMMI was harmonized with International standards. Released initial Team Software Process training.

• Adoption of Software Technologies. ($ 1.495 Million)
  - Upgraded and expanded measurement information repository was released to define the benefits and costs of technical practices; Developed measurement guidance for tracking performance at organizational and enterprise levels and developed guidance for the application of the Earned Value Management System (EVMS) to the development of software-intensive systems. Provided transition planning and measurement support to SEI maturation and transition activities.

(U) **FY 2000 Plans:**

• Software Engineering Technical Practices. ($ 11.340 Million)
  - Define and pilot a method for survivable network technology analysis. Development of security self-evaluation method and training. Version 1 of product line acquisition guidelines and courses will be made available for use by DoD. Courses for training software engineers in the development of COTS-based systems will be available. DoD-based data on the benefits and costs of architecture analysis methods will be available.

• Software Engineering Management Practices. ($ 4.687 Million)
  - Update and release of CMMI training, assessment and other products based on Government and industry use and feedback. Data available showing the benefits, costs, and appropriate conditions for use of Team Software Process.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-22

- Adoption of Software Technologies. ($ 1.200 Million)
  - Develop guidebook for introducing technology change into organizations. Additional guidance for use of metrics in software acquisition and development. Continue to provide software measurement support to all initiative work to ensure performance measures are established. Provide transition planning and measurement support to SEI maturation and transition activities.

(U) **FY 2001 Plans:**

- Software Engineering Technical Practices. ($ 11.700 Million)
  - Establish techniques for modeling and predicting survivability attributes of systems while they are under development. Exemplar architectures for survivable systems will be in use by DoD and industry. Standard COTS evaluation practices will be defined and in use to support the development of COTS-based systems.

- Software Engineering Management Practices. ($ 5.100 Million)
  - Support rollout and widespread use of integrated CMM models; extend models to additional disciplines; document benefits and costs of using the integrated models; and prepare for revision of models based on actual experience in their use.

- Adoption of Software Technologies. ($ 1.300 Million)
  - Standard practices for adopting technology are in widespread use. Provide transition planning and measurement support to SEI maturation and transition activities.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24				

COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Information Survivability ST-24	56.424	67.529	88.400	99.800	107.800	106.500	110.000	Continuing	Continuing

(U) **Mission Description:**

(U) This project is developing the technology required to protect DoD's mission-critical systems against attack upon or through the supporting information infrastructure. These technologies will enable our critical systems to provide continuous correct operation even when they are subject to attack, and will lead to generations of stronger protection, higher performance, and more cost-effective security and survivability solutions scalable to several thousand sites. Technologies developed under this project will be exploited in High Performance and Global Scale Systems (Project ST-19), Command and Control Information Systems (Project CCC-01), Information Integration Systems (Project CCC-02), and in other programs to satisfy defense requirements for secure and survivable systems.

(U) Information Assurance and Survivability technologies will be developed to mitigate national and defense computing infrastructure vulnerabilities that could be exploited by an information warfare enemy. Information Assurance and Survivability focuses on early prototypes of software technologies leading to protection for large-scale, heterogeneous systems usable over a wide range of performance in diverse threat environments. High confidence network-based systems will include security mechanisms and value-added security services for integration into network-based infrastructure as well as inherent protection mechanisms to allow the system to resist, repel and survive attack. High confidence computing systems will be developed that provide modular security services and mechanisms, provide high reliability for distributed computations, and allow geographically separated parts of an organization to interact as if they shared a common security perimeter. This also includes integrity mechanisms to allow damage to be detected rapidly. Intrusion tolerant systems will be developed to assure code integrity, confine malicious code, and to tolerate remaining attacks using survivable architectures. Intrusion detection systems will allow attacks on the defense infrastructure to be detected, the damage to be assessed, and appropriate response to be taken. Strategic intrusion assessment technologies will be developed to detect national security threats through correlation and analysis of observed/reported activities. Assurance and dynamic integration tools will allow security and survivability to be inserted into legacy systems, and will enable critical systems to reconfigure and survive in the face of detected threat and successful attack, setting the stage for autonomic information assurance. Autonomic systems will be developed to provide intelligent but reflexive defenses that adapt rapidly in milliseconds to block or withstand many classes of known and unknown attacks. Cyber Command and Control will create technologies to enable human-directed strategic oversight and guidance, to provide strategic information attack situation understanding, mission-critical functional impact assessment, and cyber course of action analysis and execution.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- High Confidence Networking. ($ 15.761 Million)
  - Demonstrated secure middleware supporting distributed applications over mobile and wireless networks.
  - Demonstrated secure, multi-policy, high speed group communication.
- High-Confidence Computing. ($ 13.892 Million)
  - Demonstrated techniques for general pairwise tradeoffs among real-time operations.
  - Evaluated prototype compiler for certifying proof-carrying code.
  - Released operating system prototype supporting efficient, secure nested virtual machines.
- Assurance and Integration. ($ 9.773 Million)
  - Completed initial wrapper-generator toolkits.
  - Demonstrated integration of security composition techniques into software engineering tools.
- Survivability of Large Scale Systems. ($ 15.510 Million)
  - Developed techniques for diagnosing multi-agent, multi-staged attack, through common Intrusion Detection Framework.
  - Demonstrated Adaptive Architecture for Survivable Systems.
  - Conducted red team exercise(s) to assess intrusion detector systems.
- Computer Security. ($ 0.992 Million)
  - Enhanced computer security through innovative security measures.
- Software Security Research. ($ 0.496 Million)
  - Develop ambiguous server location algorithms.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

(U) **FY 2000 Plans:**

- Autonomic Information Assurance. ($ 13.535 Million)
  - Identify response selection techniques for effectively handling broad classes of unknown attacks.
  - Investigate impacts and effects of dynamic response.
  - Design active techniques for trace-back and automated response.

- Cyber Command and Control. ($ 9.023 Million)
  - Develop initial situation analysis techniques to derive strategic attack hypotheses.
  - Prototype dynamic retasking of sensors to acquire missing situation information.
  - Develop capabilities for analysis and execution of directly controlled strategic response elements.

- Strategic Intrusion Assessment. ($ 13.309 Million)
  - Initial design for hierarchical reporting structure for intrusion detection systems.
  - Develop experimental methods for filtering events of purely local significance.
  - Common framework for linking intrusion assessment and response components.
  - Develop workflow model supporting dynamic response capability.

- Intrusion Tolerant Systems. ($ 14.662 Million)
  - Investigate digital integrity mark technology and information dispersal for intrusion tolerance.
  - Develop Execution Monitoring tools & techniques to significantly reduce the likelihood of malicious mobile code from compromising data integrity and confidentiality.
  - Identify mechanisms that rapidly distinguish intact and corrupted programs through automated verification of proof-carrying code.

- Fault Tolerant Networking. ($ 11.000 Million)
  - Adapt fault tolerance techniques to the networking environment balancing redundancy for availability with security requirements.
  - Investigate user capability-based resource allocation mechanisms.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

- Prototype demonstration of "push-back" techniques for denial-of-service attacks.
- Exploit active network technology for attacker fencing.

• Dynamic Coalitions. ($ 6.000 Million)
- Investigate languages and tools for specification and analysis of complex policies and translation into enforcement mechanisms.
- Augment existing Public Key Infrastructure (PKI) capabilities with protocols for rapid revocation of coalition member credentials.

(U) **FY 2001 Plans:**

• Autonomic Systems. ($ 20.010 Million)
- Develop aggregate assurance posture specification languages.
- Develop light autonomic systems capable of effective local adaptation.
- Initial design for larger scale distributed autonomic defensive systems.

• Cyber Command and Control. ($ 13.690 Million)
- Develop preliminary attack intent inference techniques.
- Design initial methods for strategic attack mission-level impact and damage analysis.
- Demonstrate analysis and execution of multi-element response tactics.

• Strategic Intrusion Assessment. ($ 15.797 Million)
- Design protocols to allow detectors and sensors to exchange information on their capabilities.
- Implement initial peer-to-peer protocols allowing detection components to suppress events of purely local significance.
- Prototype demonstration of integrated assessment and response capability.

• Intrusion Tolerant Systems. ($ 17.903 Million)
- Investigate market-based and value-based resource allocation mechanisms.
- Prototype demonstration of integrity mark technology and information dispersal supporting near continuous operation during post-attack audit.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-24

- Beta release of certifying compilers and security proof generators and checkers.
- Demonstrate Execution Monitoring techniques and tools to confine malicious mobile code.
- Investigate new approaches to intrusion tolerance based on data, spatial, temporal and analytical redundancy and market/value-based resource allocation, instead of absolute correctness; identify relevant challenge problems.

• Fault Tolerant Networking. ($ 13.000 Million)
- Develop techniques to isolate corrupted or malicious network entities.
- Investigate progress-based network resource allocation mechanisms to prevent denial-of-service.
- Investigate trust-chain techniques for network resource allocation and protection against denial-of-service.
- Design active techniques for traceback and automated response.

• Dynamic Coalitions. ($ 8.000 Million)
- Prototype protocols for negotiation of policies across coalition members.
- Create methods for fast sender authentication, scalable key distribution for creation and rekeying of coalitions.
- Extend existing PKI capabilities with protocols for cross certification of coalition members.

(U) **Other Program Funding Summary Cost:**

• Not Applicable.

(U) **Schedule Profile:**

• Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Asymmetric Threat ST-28	0.000	0.000	33.000	39.500	35.700	23.500	20.000	Continuing	Continuing

(U) Mission Description:

(U) The most serious threats to our national security, today, are *asymmetric* in nature. They are not threats of a conventional, force-on-force engagement by an opposing military, but threats of an unconventional yet highly lethal attack by a loosely organized group of transnational terrorists or other factions seeking to influence U.S. policy. The enemy force is likely to be small – only a few individuals. The weapon is likely to be unconventional – a highly lethal chemical, biological, or information attack. The target is likely to be non-military – a vulnerable civilian facility or institution. The essence of this emerging trend is that a smaller and smaller force can have an increasingly lethal impact on our national security.

(U) This new threat brings new technological challenges. Instead of being satisfied with the capability to detect a nation-state as they prepare and execute a conventional military operation, the U.S. will need to develop a capability to detect a small, loosely organized group as they plan and execute an unconventional attack. This new threat will have a smaller mass, exhibit fewer observables, and yet will be more lethal in consequence. Sparse activity that was once too insignificant to notice will need to be detected, correlated, and understood. This can only be achieved by developing a new level of automation to detect, correlate, and understand all of the observable evidence exhibited by these sparse events. Specific needs include: the capability to automatically recognize and identify humans at a distance, to detect any enemy agent performing surveillance of a U.S. target; to automatically discover, extract, and link together sparse evidence of a group's intentions and activities from vast amounts of classified and unclassified information sources; to more precisely model the beliefs and organizational behavior of these small groups to better simulate and wargame our new opponents in this asymmetric world; and to provide more effective collaborative reasoning and decision aids to improve the speed and effectiveness of distributed teams of analysts and decision-makers in these dynamic situations.

(U) The goal of this new project is to develop a suite of new technological capabilities to better detect, correlate, and understand asymmetric threats. The four programs in this project are: Human Identification at a Distance (HID), Evidence Extraction and Link Discovery (EELD), Wargaming the Asymmetric Threat (WAE), and Genoa.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

(U) The Human Identification at a Distance (HID) program objective is to develop automated multi-modal surveillance technology for identifying humans at a distance as an enabler for protection and early warning against the Asymmetric Threat. HID seeks to improve individual biometric technologies with multiple sensor signatures for multi-range, round-the-clock processing. HID focuses on multi-modal fusion of different biometrics techniques with focus on body parts identification, thermography, voice ID, kinematics and remote iris scan as a function of multiple ranges and feature presentations. The goal of this program is to positively identify humans as unique individuals (not necessarily by name) at a distance, at any time day or night, during all weather conditions, with non-cooperative subjects, possibly disguised and alone or in groups. An outgrowth of the Image Understanding for Force Protection effort, the HID program was funded under ST-11 in FY 2000.

(U) The objective of the Evidence Extraction and Link Discovery (EELD) program is to develop a suite of technologies to automatically extract evidence from vast amounts of unstructured textual data and then discover relationships among those extracted facts to provide advance warnings of potential terrorist activities. Recent advances in language understating software will be exploited to provide a capability to automatically extract facts from textual message, web pages, and other unstructured data sources. These language understanding techniques will be expanded and improved to increase the accuracy of information extraction from 60-70%, where it is today, to 90-95% so that these algorithms will be able to process vast amounts of information without human intervention.

(U) The Wargaming the Asymmetric Environment (WAE) program will provide the military commander with the ability to conduct real time operational wargaming in an asymmetric environment. Current wargames are general-purpose situation-response models that do not take into account the asymmetric threat. This project will inject adversarial behavior models into a multi-sided wargame. WAE seeks to develop operational wargaming tools that allow multi-dimensional asymmetric environments and intelligent stakeholders (adversary, friendly and neutral). These will advance current techniques, which are sequential, contain generic behavior models and are limited by scripted adversary play. This will increase the commander and analyst's ability to make operational decisions and develop collaborative gaming techniques against all adversaries simultaneously.

(U) Project Genoa will develop tools for the collective reasoning function of the asymmetric threat analysis problem and a prototype infrastructure for demonstrating these concepts and components. The growing transnational threats increase the need for early crisis discovery and mitigation. The earlier a crisis situation is discovered, identified and understood at the National Command Authority level, the easier it is to arrive at preemptive or mitigating strategies. The objectives are to: (1) decrease decision cycle time from days to hours by reducing the time it takes to go from detection of a problem to completion of a thorough briefing with actionable options for the decision maker; (2) increase number of situations that can be managed simultaneously by an order of magnitude, because with the increasing number of potential crisis situations and reduced resources we must make analysis more efficient, cover more situations and provide more diverse options; and (3) reduce number of military deployments. The key enabling technologies are: knowledge discovery of critical information from unstructured multimedia sources; structured

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

argumentation to capture and present reasoning from evidence to conclusion; and a comprehensive corporate memory which will enable comparison of critical information across situation, time, and organization. The current clients for components of the prototype system are Commander in Chief Pacific (CINCPAC) and Defense Intelligence Agency (DIA). This project was initiated and budgeted in PE 0602702E, Tactical Technology, Project TT-03, but as it has evolved, it transitioned to PE 0603760E, Project CCC-01 in FY 1999 where a small applications-oriented effort directed at Phase I technologies remains. The Phase II effort will focus specifically on the asymmetric threat and will integrate and test emerging concepts in collective reasoning applied to the asymmetric threat.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Not Applicable.

(U) **FY 2000 Plans:**

- Not Applicable.

(U) **FY 2001 Plans:**

- Human Identification at a Distance. ($ 14.000 Million)
  - Identify candidate and new biometric features that are unique, permanent and cannot be circumvented.
  - Quantify, evaluate and verify the theoretical performance limits for feature extraction at ranges based on principles of physics for multi-spectral sensors and operation configurations.
  - Develop and evaluate algorithms that may exploit adaptive processing methods to improve the range dependent performance for given sensors within realistic operational environments.
  - Develop and evaluate Fusion Experiments of multi-modal sensor fusion algorithms that offer the potential for improving identification performance.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Computing Systems and Communications Technology PE 0602301E, Project ST-28

- Evidence Extraction and Link Discovery. ($ 5.500 Million)
  - Perform a thorough linguistic analysis of sample text corpora to determine the language characteristics of the data sources of interest to asymmetric problems.
  - Develop test problems and evaluation methods for testing new information extraction techniques.
  - Perform an analysis of past case studies of asymmetric incidents to determine the relational patterns of interest for link discovery.
  - Survey and select candidate information extraction techniques for development.

- Wargaming the Asymmetric Environment. ($ 6.500 Million)
  - Develop and cross validate asymmetric model ontology with open and classified data.
  - Statistically test advanced reasoning techniques for applicability to asymmetric threats.
  - Research increased scalability for multi-dimensional wargaming. Develop challenge problems and associated test criteria.

- Genoa Phase II. ($ 7.000 Million)
  - Develop and validate emerging concepts from collective reasoning applied to the asymmetric threat.
  - Demonstrate products that will permit operations in a multi-level security environment. Incorporate changes resulting from client evaluation in real world asymmetric environment.

(U) **<u>Other Program Funding Summary Cost:</u>**

- Not Applicable.

(U) **<u>Schedule Profile:</u>**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	0.000	70.000	100.000	121.500	111.000	110.000	110.000	Continuing	Continuing
Deeply Networking Systems AE-01	0.000	25.000	13.700	13.000	27.000	32.000	42.000	Continuing	Continuing
Software for Autonomous Systems AE-02	0.000	27.000	32.300	60.500	52.000	48.000	48.000	Continuing	Continuing
Software for Embedded Systems AE-03	0.000	18.000	24.000	28.000	12.000	15.000	10.000	Continuing	Continuing
Gigabyte Applications AE-04	0.000	0.000	30.000	20.000	20.000	15.000	10.000	Continuing	Continuing

(U) **Mission Description:**

(U) This program is part of a multi-agency initiative to greatly extend the reach and effectiveness of networked computation. It is funded in the applied research budget activity because it is pursuing network and software research to facilitate the "deep networking" of computers, such as those embedded within DoD platforms and weapons. It will also conduct research to greatly increase the autonomy of those systems, so as to promote the human role from that of operator to supervisor.

(U) The Deeply Networked Systems project is developing the software for designing and managing a single complex system, which is composed of multiple sub-systems, and each sub-system has many embedded devices. The challenge is how to network these devices which are located in different sub-system/components. Doing so will require a much "deeper" approach to information systems – one that manages the vast quantities of "physical" information that can be accessed by sensors and actuators in direct contact with real world processes. To enable this transition, both the network and embedded software infrastructure must be extended to deal with: challenges created by a wide diversity of embedded devices dealing in physical world information which must be addressed by network research; vast increases in the numbers of nodes with real-time transmission requirements; and operating regimes in which network-based nodes must host services on behalf of embedded clients. Research on embedded software creation must radically extend the technology to enable the composition of software systems subject to physical constraints.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E

(U) The Software for Autonomous Systems project develops software to enable reliable, safe, and cooperative operation of free ranging, autonomous systems. This effort includes software for mobile robots (air, land or maritime unmanned vehicles) performing tasks in dynamic, unstructured (physical) environments without the need for synchronous, operator control inputs or high quality communications links. Similarly, this effort includes the development of software agents (knowbots) that can range over cyberspace performing information services, including the capability to negotiate for and assign selected resources. Further, these autonomous systems should be able to learn and adapt to change and uncertainty while improving with experience.

(U) The convergence of processing power, vanishing size and decreasing cost of today's microprocessors has created new devices and micro sensors that enable a new wave of DoD applications. For example, cheap, smart micro-sensors can be deployed quickly in large quantities in the battlefield to perform new monitoring and control functions; and a host of sensors can be attached to warfighters and assets to autonomously monitor safety and health information, and equipment condition. The Software for Embedded Systems project is developing the software for networking the untethered micro sensors in a relatively wide area environment, for example, a sensor net on the ground and water. A unique processing capability, collective processing, due to this networking environment will also be explored. This new class of software will deal with the processing of physical world information by networked embedded devices.

(U) The Gigabyte Applications project is developing the technology to enable robust operation of DoD's mission-critical systems and platforms that are inherently geographically dispersed and are dependent on extremely high data flows. Capabilities for end-applications to tie in with other applications as well as with signals from multiple hardware sources and with human users will be developed with technologies that allow ultra high-throughput, sustained low-latency data delivery and processing. Gigabyte to terabyte flow transfers across end applications will be demonstrated over wide-area networks. The project will also develop robust, survivable inter-networking architecture that will minimize vulnerability posed by the growing complexity and brittleness that is seen across physical layer networking architecture today.

(U) **Program Change Summary:** (*In Millions*)	**FY1999**	**FY 2000**	**FY 2001**
Previous President's Budget	0.000	70.000	70.000
Current Budget	0.000	70.000	100.000

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E

(U) **Change Summary Explanation:**

FY 2001 Increase reflects addition of the Gigabyte Applications project for $30 Million.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-01				
COST (In Millions)	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Deeply Networked Systems AE-01	0.000	25.000	13.700	13.000	27.000	32.000	42.000	Continuing	Continuing

(U) **Mission Description:**

(U) Extending DoD's ability to monitor and control the physical environment will require a much "deeper" approach to information systems – one that manages the vast quantities of "physical" information that can be accessed by sensors and actuators in direct contact with real world processes. To enable this transition, both the network and embedded software infrastructure must be extended to deal with: challenges created by a wide diversity of embedded devices dealing in physical world information which must be addressed by network research; vast increases in the numbers of nodes with real-time transmission requirements; and operating regimes in which network-based nodes must host services on behalf of embedded clients. Research on embedded software creation must radically extend the technology to enable the composition of software systems subject to physical constraints.

(U) The large scale networking of embedded and autonomous devices creates new requirements for: multi-mode network interface technologies that can achieve drastic reductions in costs while being compatible with a wide range of network media; and flexible mechanisms for naming, addressing, configuring and administering networks that will make the deployment and operation of a hundred billion part infrastructure feasible. These challenges are addressed in the Network Interface component of this project.

(U) Future defense uses of the network will have an increased emphasis on the direct exchange of real-time sensor-derived information among autonomous embedded devices. This reflects a significant change in network traffic from the present environment, which is dominated by the exchange of symbolic information among human users. The new traffic models, architectures and protocols needed to effect this transition will be investigated in the Near Real-Time Networking component of this project.

(U) Many applications of deeply networked systems will perform data dissemination and fusion operations that could most efficiently be performed at nodes within the network. The Agile Network Services component of this project will leverage the capabilities of a programmable network substrate to deploy middleware that is nomadic in nature and can go where network connectivity permits. This capability will permit network elements to host services on behalf of embedded and autonomous devices.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-01

(U) Tight integration of information processing with physical processes demands new technology for the integrated modeling of software and physical systems. These models will enable designers to capture complex cross cutting physical constraints that the embedded software must satisfy. The Model-Based Integration of Embedded Software component of this project will use integrated models to analyze and verify the aggregate behavior of software and physical processes, and to automatically customize, integrate system components.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Not Applicable.

(U) **FY 2000 Plans:**

- Agile Network Services and Fine-Grained Networking. ($ 8.000 Million)
  - Develop framework for automated migration of client specified proxy services to internal network nodes.
  - Specify client server architecture for embedded devices.
  - Investigate and develop new protocols that minimize overhead for communicating short flows.
  - Design new naming and routing paradigm that streamline end-to-end throughput.

- Near Real-Time Networks. ($ 17.000 Million)
  - Investigate new modeling methods capturing cross-cutting physical constraints in embedded systems such as avionics and vetronics.
  - Develop customizable modeling tools that can be rapidly adjusted to different modeling views and application domains.
  - Investigate new generation technology with capability to configure, customize and synthesize software directly from models.

(U) **FY 2001 Plans:**

- Agile Network Services and Fine-Grained Networking. ($ 3.700 Million)
  - Develop capability to support the migration of continuously operating client proxy services.
  - Develop efficient name lookup and binding algorithms for large-scale embedded components.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-01

  - Implement and demonstrate application non-specific congestion manager that coordinates and ensures fair throughput for multiple applications.
  - Implement high-speed routers that integrate name resolution and forwarding functions.

- Model-Based Integration of Embedded Software. ($ 10.000 Million)
  - Develop modeling tools that can manage overlapping modeling views.
  - Investigate methods for the mathematical modeling and composition of model-based software generators.
  - Develop customizable frameworks for embedded software.
  - Demonstrate the rapid synthesis of embedded systems using customizable frameworks and model-based generators.

(U) **<u>Other Program Funding Summary Cost:</u>**

- Not Applicable.

(U) **<u>Schedule Profile:</u>**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)						DATE September 1999			
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-02				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Software for Autonomous Systems AE-02	0.000	27.000	32.300	60.500	52.000	48.000	48.000	Continuing	Continuing

(U) **Mission Description:**

(U) This project develops software to enable reliable, safe, and cooperative operation of free ranging, autonomous systems. This effort includes software for mobile robots (air, land or maritime unmanned vehicles) performing tasks in dynamic, unstructured (physical) environments without the need for synchronous, operator control inputs or high quality communications links. Similarly, this effort includes the development of software agents (knowbots) that can range over cyberspace performing information services, including the capability to negotiate for and assign selected resources. Further, these autonomous systems should be able to learn and adapt to change and uncertainty while improving with experience.

(U) Autonomous Systems will enable revolutionary, asymmetric military capabilities, such as the ability to autonomously convey military payloads (both lethal and non-lethal) to any portion of the battlefield without requiring human operators and the ability to autonomously retrieve, process and deliver information.

(U) The Common Software for Autonomous Robotics component of this project will develop a combination of critical, enabling software technologies that can be reused across a wide range of mobile autonomous robotic systems.

(U) The Software Enabled Control component will leverage increased processor and memory capacity to vastly increase our ability to maintain control over mobile devices through the development of novel techniques, such as: predictive mode changes, dynamic control scheduling, composable control and dynamic sensor and actuator allocation.

(U) The Negotiation component will enable the autonomous operation of large collections of agents negotiating resource allocation issues, such as those encountered in logistics and countermeasures.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-02

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Not Applicable.

(U) **FY 2000 Plans:**

- Common Software for Autonomous Robotics. ($ 13.900 Million)
  - Develop architectures for the integration of deliberative, reactive and learning behaviors, including knowledge representations.
  - Develop alternative approaches to combining machine learning with direct programming at various levels of abstraction.
  - Identify strategies to account for, manage and (where appropriate) integrate emergent behaviors.
  - Identify and develop alternative computational approaches to software for distributed robotics.

- Software Enabled Control. ($ 9.000 Million)
  - Specify architecture for a hybrid control system that synthesizes the control law approach with computationally-enabled mode logic scalable to very large state spaces of 100K+ states.
  - Develop active transition control and joint mode logic/control law designs.
  - Implement tools for active model creation, augmentation, and query.

- Agent Based Negotiation. ($ 4.100 Million)
  - Develop framework for bottom-up organization of autonomous software.
  - Define strategy for tasking and consolidation of responses from large numbers (thousands) of software agents with minimal human intervention.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-02

(U) **FY 2001 Plans:**

- Common Software for Autonomous Robotics. ($ 20.000 Million)
  - Prototype demonstration and experimental evaluation of integrated deliberative, reactive and learning behaviors.
  - Laboratory demonstration of compatible knowledge representations for reprogrammable, behavior-based control.
  - Laboratory demonstration and experimental evaluation of domain specific language-derived capabilities for directly programmed portion of the software for autonomous mobile robots.
  - Experimental evaluation of networking protocols for distributed robot controls that are more energy efficient than conventional implementations.
  - Prototype demonstration and experimental evaluation of software for distributed robotics capable of coordinating the operation of 10+ devices in a collective task.

- Software Enabled Control. ($ 9.800 Million)
  - Alpha-level prototype implementation of multi-mode control architecture and framework.
  - Develop parametric predictive and adaptive control frameworks.
  - Complete multi-level, multi-modal advanced design tools.

- Agent Based Negotiation. ($ 2.500 Million)
  - Prototype demonstration of autonomous software ability to utilize negotiation in logistics scenario.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-03				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Software for Embedded Systems AE-03	0.000	18.000	24.000	28.000	12.000	15.000	10.000	Continuing	Continuing

(U) <u>Mission Description:</u>

(U) This project develops a new class of software to deal with the processing of physical world information by networked embedded devices. The convergence of processing power, vanishing size and decreasing cost of today's microprocessors has created new devices and micro-sensors that enable a new wave of DoD applications. For example, cheap, smart micro-sensors can be deployed quickly in large quantities in the battlefield to perform new monitoring and control functions; and a host of sensors can be attached to warfighters and assets to autonomously monitor safety and health information, and equipment condition.

(U) Harnessing the full potential of micro-sensors and embedded devices requires addressing new information technology challenges. Networking these untethered devices creates new requirements on hardware and software, including rapid self-assembly, timely acquisition, processing and exchange of sensor data, and energy efficient operation. Accurate identification of events and collection of information require new ways of cooperation among these devices to process physical world signals, and to integrate information in the network. Additionally, remote querying and accessing data collected by the sensor net should be simple with easy to use interfaces.

(U) This project will build on Software and Networking R&D activities, extending and specializing them to geographically distributed micro-sensor networks. A major challenge is the development of software technologies that spans a variety of sensor nets, on ground and water, on buildings and bodies. Another challenge is to design reliable networked embedded systems retaining only supervisory control, while automating traditional "in-the-loop" tasks. The sensor tasking, data collection, integration and analysis must be fully automated to enable operation within time constraints far shorter than could be achieved by human operators.

(U) As software systems become more complex, they must be able to reconfigure and evolve themselves dynamically, while the system is in operation. This project will develop the dynamic gauges or measures of composability necessary to enable software components from any source to support assured applications (Dynamic Assembly for Systems Adaptability, Dependability and Assurance (DASADA)). Outputs from this program will ensure that the critical properties of complex, heterogeneous software systems are maintained during and after composition, adaption and deployment.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-03

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Not Applicable.

(U) **FY 2000 Plans:**

- Large Scale Networks of Sensors. ($ 12.000 Million)
  - Specify gradient-based approach to automated aggregation and distribution of information from large numbers of multi-taskable sensor nodes.
  - Develop methods for optimized collaborative signal processing and information integration.
  - Explore energy efficient designs; develop experimental platform and simulation capability.

- Declarative Tasking and Querying of Embedded Systems. ($ 6.000 Million)
  - Investigate use of declarative interfaces for tasking and querying of networked embedded systems; develop experimental prototype based on relational database query technology and lightweight operating environment.
  - Investigate suitability of aspect-oriented approaches to specification and generation of embedded systems software.

(U) **FY 2001 Plans:**

- Large Scale Networks of Sensors. ($ 12.000 Million)
  - Implement experimental prototype supporting automated aggregation and distribution of sensor derived information involving at least 50 nodes and 100 sensors.
  - Develop methods for efficient interoperation of fixed and mobile sensors.
  - Implement networked detection, estimation, tracking, and information integration.
  - Demonstrate multi-node sensor network software and benefits of collaborative signal processing for operations in an urban terrain.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-03

- Declarative Tasking and Querying of Embedded Systems. ($ 5.000 Million)
  - Prototype demonstration using declarative interfaces for tasking and querying of multi-taskable sensor networks.
  - Specify interfaces supporting common run-time services required by signal processing and generation applications.
  - Develop incremental (off-line/on-line) code analysis and simple merge tool and apply to functional and mechanism code.

- Dynamic Assembly for Systems Adaptability, Dependability and Assurance (DASADA). ($ 7.000 Million)
  - Conduct preliminary demonstrations of dynamic software component composability with multiple standard communication (e.g. Distributed Component Object Model (DCOM), Common Object Request Broker Architecture (CORBA), Distributed Computing Environment (DCE)) or structuring (e.g., Extended Markup Language (XML), Resource Description Framework (RDF), Document Object Model (DOM)) infrastructures.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project AE-04				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost to Complete	Total Cost
Gigabyte Applications AE-04	0.000	0.000	30.000	20.000	20.000	15.000	10.000	Continuing	Continuing

(U) **Mission Description:**

(U) This project is developing the technology to enable robust operation of DOD's mission-critical systems and platforms that are inherently geographically dispersed and are dependent on extremely high data flows. Capabilities for end-applications to tie in with other applications as well as with signals from multiple hardware sources and with human users will be developed with technologies that allow ultra high-throughput, sustained low-latency data delivery and processing. Gigabyte to terabyte flow transfers across end applications will be demonstrated over wide-area networks. The project will also develop robust, survivable inter-networking architecture that will minimize vulnerability posed by the growing complexity and brittleness that is seen across physical layer networking architecture today.

(U) The efforts will leverage some of the advances made within earlier programs for high-speed communications and networking, but will largely target breakthroughs in DoD focused gigabyte applications, in gigabyte dataflows over wireless as well as wireline infrastructure, and in enhancing the robustness of these heterogeneous links and resources. Advances in architectural work and tools in ultra-high-performance heterogeneous flow-based communications will be pursued to enable a large number of end applications with extremely diverse traffic characteristics – expected for DoD supporting applications - to be simultaneously deployed. With the optical communications techniques that can now support many hundreds of Gbps data transfer over terrestrial fiber cables, there exists today a huge bandwidth gap between wireless and wired link capability. In the Gigabit Multi-Link component of this project, new gigabit per second communication capabilities over alternate physical media will be demonstrated such that gigabyte flow transfers can be demonstrated to sites lacking in fiber infrastructure and connectivity. Multi-channel techniques in temporal, spatial, and spectral domains will be invoked to enable the new capabilities. Finally, robustness of applications built atop diverse logical and physical infrastructure will be ensured with the development of new software and hardware tools that can automatically track and assess the inter-dependencies of physical layer resources.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project Gigabyte Applications AE-04

(U) **FY 2000 Plans:**

- Not Applicable.

(U) **FY 2001 Plans:**

- Ultra-High Performance Heterogeneous Flow-Based Communications. ($ 7.300 Million)
  - Develop soft-physical interfaces that can adapt or be programmed to support diverse link protocols, symbol rates and signaling technologies.
  - Demonstrate the gateway technology that can segregate long flows from short flows.
  - Prototype implementation for transparent, vertical handoff between flow-based and circuit-based connectivities.

- Gigabit Multi-Link. ($ 7.500 Million)
  - Demonstrate an order of magnitude increase in wireless spectral efficiency for non-mobile end nodes.
  - Establish feasibility of 10 Gbps transmission over 10km free-space link.
  - Demonstrate adaptive multi-link coding technique to enhance immunity to degradations due to mobility or environmental (weather, obstruction) changes.

- Robust Physical and Logical Configurations. ($ 6.900 Million)
  - Develop architectural framework for ensuring maximum end-to-end system survivability.
  - Prototype tool for assessing dependence of applications or networking performance on physical layer resources.
  - Specify robust heterogeneous network architecture that integrates gigabit wireless, wireline and satellite communications.

- Defense Applications. ($ 8.300 Million)
  - Develop virtual radar console tied to a physical radar and remotely accessible via wide-area network.
  - Demonstrate real-time, high-resolution imagery transfer over multiple streams of multi-gigabyte flows.
  - Enable streaming of raw (undigitized) sensor signal over wide-area links.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Extensible Information Systems PE 0602302E, Project Gigabyte Applications AE-04

(U) **<u>Other Program Funding Summary Cost:</u>**

- Not Applicable.

(U) **<u>Schedule Profile:</u>**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	84.043	145.850	168.000	177.000	190.000	215.000	225.000	Continuing	Continuing
Biological Warfare Defense Program BW-01	84.043	145.850	168.000	177.000	190.000	215.000	225.000	Continuing	Continuing

(U) **Mission Description:**

(U) DARPA's Biological Warfare Defense program is budgeted in the Applied Research budget activity (BA-2) because its focus is on the underlying technologies associated with pathogen detection and remediation. Today, there is a tremendous mismatch between the magnitude of the biological warfare threat and the Department's ability to adequately respond. The widespread availability of bacterial, viral, and toxin stocks; minimal developmental cost and scientific expertise required; and abundance of weaponization potential comprises a sinister threat. The single largest concern, however, is from the exploitation of modern genetic engineering by adversaries to synthesize "super pathogens." Recent dramatic developments in biotechnology, which this program will leverage, promise to eliminate this mismatch. This program funds projects supporting revolutionary new approaches to biological warfare (BW) defense and does not duplicate efforts of other government organizations.

(U) Efforts to counter the BW threat include developing barriers to block entry of pathogens into the human body (including unique methods for rapid air and water purification), pathogen countermeasures to stop pathogen virulence and to modulate host immune response, medical diagnostics for the most virulent pathogens and their molecular mechanisms, biological and chemically-specific detectors, and consequence management tools. Program development strategies include collaborations with pharmaceutical, biotechnology, government, and academic centers of excellence.

(U) Pathogen countermeasures (e.g., Anti-Virals/Immunizations, Anti-Bacterials/Anti-Toxins, Multi-Purpose, and External Protection) under development include: (1) multi-agent therapeutics against known, specific agents and (2) therapeutics against virulence pathways shared by broad classes of pathogens. Specific approaches include modified red blood cells to sequester and destroy pathogens, modified stem cells to detect pathogens and produce appropriate therapeutics within the body, identification of virulence mechanisms shared by pathogens, development of therapeutics targeting these mechanisms, efficacy testing in cell cultures and animals, and advanced non-toxic decontamination strategies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

(U) In the early stages, many illnesses caused by BW agents have flu-like symptoms and are indistinguishable from non-BW related diseases. Early diagnosis is key to providing effective therapy. The advanced diagnostics efforts will develop the capability to detect the presence of infection by biological threat agents, differentiate them from other significant pathogens, and identify the pathogen even in the absence of recognizable signs and symptoms (when the pathogen numbers are still low).

(U) The ability to detect biological warfare agents on the battlefield in real time with a low false-alarm rate is a crucial requirement. To address this need, the program is creating more efficient and effective miniature sampling technologies that concentrate contaminated air and enhance the ability to capture biological warfare agents. The program is developing a new range of antibodies and "designer small molecules" to bind specific agents (to replace the lower affinity antibodies currently used). In order to detect that the binding of an agent has occurred, the event must be "magnified." Traditionally, this is done by tagging the antibody molecule with a fluorescent probe. This program is replacing the noise-plagued fluorescent tags with Up-Converting Phosphors with the sensitivity to detect a single binding event, minimizing the size of the sample required, saving time, and decreasing the number of false positive alarms. The use of fluids as a requirement for biological agent detection is also being eliminated and replaced by a miniaturized (shoe box-size) time-of-flight mass spectrometer. Development of a bacterial biochip to identify genus and species without multiplying the DNA by the polymerase chain reaction (PCR) is also under development, thereby saving at least 20 minutes in time to identification. Additional efforts are focusing on the construction of molecular, cellular, and multicellular sensors for the rapid detection of biological threats. These cellular and tissue-based sensors have the ability to respond to both known and unknown threats, determine live vs. inactivated threat status, and report functional consequences of exposure (mechanisms of action). The use of organisms such as insects are also being explored as information collectors for environmental biological or chemical threats. A variety of applications for these sensors are being explored including protection of buildings from a biowarfare agent attack.

(U) Mission effectiveness requires rapid, correct medical responses to biological weapon threats or attacks. This project will provide comprehensive protocols to protect or treat combatants by using current and emerging biological countermeasures. It will provide accelerated situational awareness for biological warfare events by detecting exposure to agents through an analysis of casualty electronic theater medical records and will locate and determine the most effective logistical support for providing appropriate treatment and pathogen-specific resources required to mitigate effects of the attack.

(U) DARPA is working with a number of governmental organizations to exploit recent advances in high throughput genetic sequencers to obtain complete genetic information on a number of important pathogens and their non-pathogenic nearest neighbors. This will allow us to develop

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

an inventory of genes and proteins that distinguish pathogens from non-pathogens and to identify pathogenic markers in any guise. This information will be used to provide superior molecular targets and enable new generations of detectors, diagnostics, and therapeutics.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Anti-Virals/Immunizations. ($ 14.820 Million)
  - Developed a modified stem cell, which can both detect and produce a prophylactic/therapeutic response to a pathogen (in cell culture).
  - Determined (in-vitro) toxicity of modified stem cell-produced therapeutics.
  - Created techniques to rapidly develop immunization strategies against bacterial and viral pathogens and toxins.

- Anti-Bacterials/Anti-Toxins. ($ 14.858 Million)
  - Developed and tested (in-vitro) cellular platforms for toxin destruction and toxin binding decoys.
  - Demonstrated selected strategies (in cell culture) to:
    Inhibit the expression of disease causing (virulence) factors by pathogens.
    Disrupt the disease causing (virulence) communications between pathogens.
    Modulate the body's response to the presence of a pathogen.

- Multi-Purpose. ($ 12.000 Million)
  - Defined animal models in which to test the efficacy of modified stem cells to prevent disease.
  - Demonstrated in laboratory animals the efficacy of modified red blood cells to eliminate pathogens from the blood for the purpose of potential defense against biological warfare agents.
  - Determined pathogen detection and elimination efficacy for modified red blood cells with enzymes or other active molecules attached to their surfaces.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- External Protection. ($ 6.483 Million)
  - Developed polymeric materials for pathogen protection.
  - Demonstrated in-vivo broad-spectrum efficacy of non-toxic biological decontamination formulation.

- Advanced Diagnostics. ($ 10.900 Million)
  - Determined appropriate bodily sample types (blood, saliva, sputum, etc.) to use for diagnosis.
  - Determined which non-biological warfare (BW) pathogens must be screened against because they mimic early symptoms of known BW threat agents.
  - Began identification of probes to be used in diagnosis systems.
  - Evaluated the feasibility of novel technologies and sampling strategies, such as detecting bodily responses indicative of infection.

- Sensors. ($ 15.390 Million)
  - Continued development of air sampling technology for airborne biological materials.
  - Determined chemotaxonomic biomarkers for selected viral substances for detection in the mass spectrometer.
  - Demonstrated replacement of a surface-bound antibody with a "designer" small molecule for high affinity pathogen capture.
  - Developed a high affinity monoclonal antibody that recognizes only anthrax spores without cross-reactivity with vegetative cells (or other bacillus species) and tested in existing BW sensors for improved performance.
  - Completed Up-Converting Phosphors (UCP) detection system and field test.
  - Modified the prototype of a miniature biodetection system following Dugway Proving Ground test results.
  - Selected cell and tissue types for the development of tissue based sensors.
  - Examined and selected strategies to stabilize cell systems for long-term shelf life and functional response.
  - Demonstrated the ability to modify the duty cycle of a cellular response in single cell and tissue based sensors.
  - Demonstrated performance limits of a single cell sensor.

- Consequence Management. ($ 8.600 Million)
  - Developed prototype software toolkit for Enhanced Consequence Management Planning and Support System (ENCOMPASS).
  - Conducted field tests of BW defense attack response planning tools and Electronic Watchboard.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Developed electronic watchboard architecture and BW incident playbook authoring and maintenance tools.
- Incorporated USAMRIID biological warfare agent treatment directives into playbooks and accelerated development of Biological Agent Symptom Information System (BASIS).

• Multimedia/Telemedicine. ($ 0.992 Million)
  - Developed an enhanced telemedicine capability for the warfighter by augmenting/tailoring wireless communication technologies appropriate for responses to biological warfare attacks.

(U) **FY 2000 Plans:**

• Anti-Virals/Immunizations. ($ 20.500 Million)
  - Identify broad-spectrum strategies with potential for immunomodulatory activity against multiple pathogens.
  - Develop a method of mucosal immunization based upon high level expression of pathogen antigens and epithelial transport molecules in edible transgenic plant products.
  - Develop technologies for rapid design and development of new vaccines against novel pathogens.
  - Demonstrate (in-vitro) candidate anti-viral and anti-bacterial small molecule therapeutics for selected targets.
  - Demonstrate (in-vivo) the efficacy of anti-viral peptides derived from hematopoietic stem cells.

• Anti-Bacterials/Anti-Toxins. ($ 18.300 Million)
  - Develop (in-vitro) broad spectrum, superantigenic, anti-toxin antagonists and vaccines.
  - Validate the efficacy (in-vivo) of antagonists to toxin receptors, toxin catalytic sites, and cellular platforms for toxin destruction.
  - Demonstrate (in-vivo) toxin-blocking antibodies and toxin binding decoys.
  - Demonstrate (in-vivo) the efficacy of a broad-spectrum bacterial antagonist.
  - Use gene-shuffling techniques to generate molecules to be screened for superantigenic properties.

• Multi-Purpose. ($ 20.000 Million)
  - Explore concepts for therapeutics against bioregulators and other mid-spectrum agents.
  - Identify primary harmful immune responses to biological warfare (BW) agents.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E	

- Explore concepts for optimizing human immune response to BW agents, minimizing negative sequelae.
- Demonstrate in laboratory animal models the ability of modified stem cells to prevent disease.
- Develop synthetic polymer complements for pathogenic antigens and virulence factors.
- Identify monomeric and dimeric DNA and RNA binding molecules as novel countermeasures against multiple pathogens.
- Identify polyvalent inhibitors for inhibiting pathogens on the surface of target cells in-vivo.

• External Protection. ($ 18.500 Million)
  - Develop decoy molecules that will prevent the adhesion of multiple pathogenic toxins or viruses in-vivo.
  - Demonstrate (in-vivo) a non-specific surfactant agent to neutralize biological threat agents.
  - Demonstrate initial performance of a prototype device for the purification of water contaminated with BW agent simulants.
  - Explore high throughput methods for the purification of contaminated air.
  - Demonstrate effectiveness of specific personnel protective toxin and pathogen neutralization strategies against virulent biological agents.
  - Continue development of prototype protective system and initiate integration into personnel protective systems.

• Advanced Diagnostics. ($ 18.700 Million)
  - Continue identification and development of probes to be used in diagnosis systems, and begin testing of probe panels in the laboratory.
  - Develop sample preparation techniques to optimize speed, accuracy, and reliability of diagnosis.
  - Identify one or more promising strategies for rapid detection based on bodily responses or other biomarkers to provide early indication of infection or exposure (including non-invasive early detection of disease [e.g., nitric oxide in exhaled breath]).
  - Determine range of cytokine levels in healthy bodies versus infected bodies using laboratory animals and cell cultures as models.
  - Determine feasibility of engineering red blood cells to detect and signal pathogen presence in the body.
  - Determine feasibility of rapid single molecule DNA sequencing for accelerated patient diagnosis.
  - Explore concepts for diagnosing patients for bio-regulator and other mid-spectrum agent attack.

• Sensors. ($ 33.850 Million)
  - Complete, test, and verify first-generation prototype of live agent biochip sensor.
  - Complete development of air sampling technology for airborne biological material.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Continue development of effective and rapid chip-reading capability with enhanced sensitivity.
- Continue the development of unique signatures for bio-agents in mass spectrometry identification.
- Develop biosensor technology for next-generation (bioengineered) threat agents.
- Develop methods for identifying bioregulator-based BW agents.
- Evaluate chemical clues used by biological systems in normal hunting strategies to revector the biological systems to search for BW agent production or storage.
- Explore options (e.g., training, genetic engineering, etc.) for the use of invertebrates in the detection of BW agents and associated chemicals.
- Construct cell and tissue engineered configurations to enhance optical or electrical signal output from the sensor.
- Optimize electronic interfaces for optical and electrical reporting from cell and tissue based sensors.
- Investigate optimal system designs for deployment of a single cell and tissue based biosensor, which incorporate environmental sampling, microfluidics, and automated detection.
- Evaluate cell and tissue based informatics from temporal and spatial signals in cell and tissue-based sensors.
- Explore shelf-stabilization strategies for cells and tissues.
- Develop bio-agent sensors and other technologies for use in building protection.
- Develop the capability to predict flow of airborne bio-agents in and around buildings.
- Explore use of organisms for the collection of chemical and biological warfare agents.
- Develop neutralization and decontamination techniques appropriate to buildings.

• Genetic Sequencing of Biological Warfare Agents. ($ 4.000 Million)
- Develop inventory of DoD-relevant BW agent pathogens requiring sequencing.
- Determine best methods for rapidly sequencing biological warfare pathogens and related species and strains.
- Begin development of database mining techniques to find new targets for sensors, diagnostics, and therapeutics.

• Consequence Management. ($ 12.000 Million)
- Develop distributed BW consequence management smart checklists for automatic pull and push of required information.
- Continue development of Enhanced Consequence Management Planning and Support System (ENCOMPASS) software toolkit.
- Develop automated checklists for BW attacks and incorporate Incident Command System capabilities.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Demonstrate use of ENCOMPASS for OCONUS air base force protection against a BW attack.
- Demonstrate use of playbooks and automated checklists for training BW incident responders.
- Integrate Consequence Assessment Tool Set (CATS) with Electronic Watchboard using the ENCOMPASS architecture.

(U) **FY 2001 Plans:**

- Anti-Virals/Immunizations. ($ 22.700 Million)
  - Validate (in-vivo) a method of mucosal immunization based upon high level expression of pathogen antigens and epithelial transport molecules in edible transgenic plant products.
  - Test and validate (in-vivo) the protective efficacy of vaccines and antibodies produced by plant cells against pathogens.
  - Demonstrate efficacy of the rapid and efficient delivery of pathogen antigens via new genetic vaccine vectors.
  - Demonstrate (in-vivo) the rapid design and development of new vaccines (or therapeutics) against unidentified or unknown pathogens.
  - Demonstrate broad-spectrum strategies with potential for immunomodulatory activity against multiple pathogens.

- Anti-Bacterials/Anti-Toxins. ($ 20.900 Million)
  - Demonstrate surface expression of specific enzyme molecules for the rapid inactivation of various pathogens.
  - Demonstrate (in-vivo) the efficacy of a broad-spectrum bacterial pathogen antagonist.
  - Validate (in-vivo) broad spectrum, superantigenic, anti-toxin antagonists and vaccines.
  - Demonstrate (in-vivo) efficacy of broad spectrum, superantigenic, antitoxin antagonists and vaccines.

- Multi-Purpose. ($ 22.300 Million)
  - Develop therapeutic strategies against bioregulators and other mid-spectrum agents.
  - Demonstrate synthetic polymer complements for pathogenic antigens and virulence factors.
  - Develop therapeutic strategies for minimizing harmful immune responses to biological warfare agents.
  - Demonstrate (in-vitro) the efficacy of monomeric and dimeric DNA and RNA binding molecules as novel countermeasures against multiple pathogens.
  - Validate polyvalent inhibitors for blocking pathogens on the surface of target cells in-vivo.
  - Identify superantigens for broad protection against biological warfare agents with minimal side effects.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

  - Validate (in-vivo) the efficacy of subcellular pathogen response imaging for rapid detection.
  - Validate technologies broadly applicable to enhance cellular therapeutics (delivery platforms) and virulence modulation (intracellular and inflammatory cascades).

- External Protection. ($ 22.600 Million)
  - Develop a novel architectural approach for the manufacture of materials that are effective in blocking pathogens and limiting disease.
  - Demonstrate a non-aqueous advanced decontamination method.
  - Demonstrate a water purification system effective against a range of biological agents (including toxins and bioregulators).
  - Build and test a prototype air purification system for collective protection for a group of soldiers.
  - Begin testing of prototype protective system against non-virulent biological warfare (BW) agents.
  - Begin testing of prototype protective system against bio-toxins and bio-regulators.

- Advanced Diagnostics. ($ 22.950 Million)
  - Test probe panels in relevant sample types including strategies for rapidly generating new/novel probes.
  - Demonstrate that sample collection and/or preparation techniques do not introduce artifacts.
  - Test, in model systems, one or more of the most promising candidate strategies for rapid detection based on bodily responses or other biomarkers to provide early indication of infection or exposure.
  - Develop the capability to diagnose exposure to bio-regulator and mid-spectrum agents.
  - Demonstrate, in the laboratory, the feasibility of engineering red blood cells to detect and signal pathogen presence in the body.
  - Evaluate the feasibility of a strategy for detection of disease using exhaled breath.
  - Evaluate the feasibility of additional strategies for direct identification or detection of infection without direct sample collection.
  - Demonstrate the ability to perform accelerated patient diagnosis using a rapid single molecule DNA sequencing technique in a model system.

- Sensors. ($ 34.050 Million)
  - Develop effective and rapid chip-reading capability with enhanced sensitivity and low false alarm rate.
  - Develop advanced alternative technologies for live vs. dead bio-agent identification using peptides and other molecules.
  - Evaluate methods for removing micro-encapsulation of disguised pathogens and/or sensing through the micro-encapsulation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

- Develop technologies required for next-generation miniature biological detectors including the use of microelectromechanical systems (MEMS), microfluidics, and mesoscopic-sized components.
- Evaluate false positive and false negative rates for systems of detectors using biomolecular cells or tissues.
- Exploit and/or mimic the olfactory sensors of biological systems for use in the detection of biological warfare agents.
- Engineer a deployable prototype cell and tissue sensor for field-testing.
- Demonstrate enhanced signal output from engineered cells and tissue based sensors.
- Integrate information from cell and tissue sensors with user interfaces for predictive responses.
- Develop concepts for sensors capable of detecting biological warfare agent production in underground facilities.
- Investigate critical design parameters for advanced biologically based biological warfare (BW) sensor.
- Validate biowarfare-agent sensors and other technologies for use in building protection.
- Develop the capability to predict the flow of airborne biowarfare-agents in and around buildings.
- Determine optimal sensor placement for building protection.
- Demonstrate use of organisms to collect chemical and biological warfare agents in the field.

• Genetic Sequencing of Biological Warfare Agents. ($ 12.500 Million)
  - Continue the genomic sequencing of high-threat known and potential biowarfare agents.
  - Continue development of database mining techniques and test on a subset of pathogenic genomes.

• Consequence Management. ($ 10.000 Million)
  - Demonstrate rapid construction and distribution of specific BW smart checklists for multiple responders.
  - Demonstrate Enhanced Consequence Management Planning and Support System (ENCOMPASS) management of multi-site BW incidents.
  - Demonstrate automatic construction of incident- and responder-specific playbooks and electronic watchboards.
  - Demonstrate use of ENCOMPASS for CONUS air base force protection against BW attacks.
  - Transition ENCOMPASS to National Guard Rapid Assessment and Initial Detection Units and to Air Force Theater Battle Management Core.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Biological Warfare Defense PE 0602383E

(U) **Program Change Summary:** (*In Millions*)

	FY1999	FY 2000	FY 2001
Previous President's Budget	84.754	145.850	151.000
Current Budget	84.043	145.850	168.000

(U) **Change Summary Explanation:**

FY 1999 Decrease reflects SBIR reprogramming and minor program repricing.

FY 2001 Increase reflects Departmental direction to continue the demonstration of complete genomic sequencing of high-threat known and potential biowarfare agents (+$10 million); and expansion of on-going efforts under diagnostics and therapeutics and external protection (+$7 million).

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	161.709	137.626	127.937	163.830	196.314	225.942	239.306	Continuing	Continuing
Naval Warfare Technology TT-03	20.382	7.619	7.807	14.640	26.717	40.774	40.615	Continuing	Continuing
Advanced Land Systems Technology TT-04	37.204	38.290	33.321	39.854	44.831	44.688	44.529	Continuing	Continuing
Advanced Targeting Technology TT-05	0.000	0.000	0.000	8.400	16.700	26.700	36.700	Continuing	Continuing
Advanced Tactical Technology TT-06	44.823	40.244	32.463	47.968	47.673	43.530	43.371	Continuing	Continuing
Aeronautics Technology TT-07	29.888	31.385	29.346	18.168	35.593	45.450	49.291	Continuing	Continuing
Advanced Logistics Technology TT-10	20.118	10.352	15.000	24.800	24.800	24.800	24.800	Continuing	Continuing
Joint Logistics ACTDs TT-11	9.294	9.736	10.000	10.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because it supports the advancement of concepts and technologies to enhance the next generation of tactical systems. The Tactical Technology program element funds a number of projects in the areas of Naval Warfare, Advanced Land Systems, Advanced Targeting, Aeronautics, and Logistics technologies.

(U) The Naval Warfare Technology project is focusing on enabling technologies for a broad range of naval requirements. Programs include: High Energy Density Materials, Submarine Payloads and Sensors, and the Underwater Navigation Program. The High Energy Density Materials

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E

program is exploring high risk/high pay-off breakthroughs in missile propellants and explosives technologies. The Submarine Payloads and Sensors effort will explore submersible platforms designed to maximize payload capacity. The Underwater Navigation Program will develop innovative geolocation capabilities for future underwater autonomous vehicles.

(U) The Advanced Land Systems Technology project is developing technologies for contingency missions, mine clearing, and anti-personnel landmine alternatives to make U.S. combat forces more deployable, effective, survivable, and affordable. The SLID program will develop and test a system for providing protection against missiles and projectiles with explosive warheads. The Advanced Fire Support Systems program will provide rapid response and lethality associated with gun and missile artillery, thereby increasing survivability, yet requiring fewer personnel and less logistical support. The Counter-artillery Force Protection program will explore advanced sensors, munitions and deployment concepts to counter evolving threats. The Dog's Nose/Unexploded Ordnance Detection program will develop sensors for the chemically specific detection of explosives or other chemicals, comparable to the effectiveness of canine olfaction detection. The Alternatives to Antipersonnel Landmines program will explore technologies to obviate the need for mines. The Close-In Sensing program will emphasize new approaches to detect traditionally low signal-to-signal noise or concealed targets. The Advanced Peacekeeping program will develop sensors and algorithms to aid US and coalition partners in peacekeeping operations.

(U) The Advanced Tactical Technology project is exploring the application of compact lasers; high performance computational algorithms to enhance performance of radars, sensors, communications, and electronic warfare and target recognition and tracking systems; precision optics components for critical DoD applications; miniature air-launched decoy systems; affordable rapid response missile demonstrations; new tactical systems for enhanced air vehicle survivability, advanced airbreathing weapons, enabling technologies for advanced space systems; and emerging payload delivery concepts.

(U) The Aeronautics Technology project will develop and demonstrate a new family of Micro-Air Vehicles (MAVs). The MAVs will be an order of magnitude smaller than any operational UAV and will be useful in a wide variety of military missions from covert imaging and chemical/biological agent detection to communication enhancement. This project also funds the Micro Adaptive Flow Control program, small-scale propulsion system concepts, the Advanced Rotorcraft Technology program, and the Vertical Take-off and Landing Unmanned Air Vehicle program.

(U) The Advanced Logistics project is investigating and demonstrating technologies that will make a fundamental difference in transportation and logistics. The program will define, develop, and demonstrate fundamental enabling technologies that will permit forces and sustainment materiel to be deployed, tracked, refurbished, sustained, and redeployed more effectively and efficiently.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E

(U) The Joint Logistics project is composed of two Advanced Concept Technology Demonstrations (ACTDs) that will develop and migrate interoperable web-based joint logistics decision support tools (JDSTs) to the Service logistics communities. The Joint Logistics ACTD will develop JDST capabilities in the areas of force capability assessments, logistic support concept generation and evaluation, distribution, materiel management; maintenance analysis and visualization. The Joint Theater Logistics ACTD will integrate and expand those capabilities to provide realtime in-theater management and analysis tools. Focus areas for the Joint Logistics project correspond to Commander-In-Chief (CINC) and Service requirements to develop JDSTs.

(U) **Program Change Summary:** (*In Millions*)	**FY1999**	**FY 2000**	**FY 2001**
Previous President's Budget	169.759	137.626	123.937
Current Budget	161.709	137.626	127.937

(U) **Change Summary Explanation:**

FY 1999 Decrease reflects SBIR reprogramming; transfer of Simulation Based Design Program to the Defense Logistics Agency; the FY 1999 Omnibus reprogramming; and minor below threshold reprogrammings.

FY 2001 Increase reflects net effect of decreases in Projects TT-07 and TT-04 for transition of the Micro Air Vehicles program and reprioritization of Simulated Battlefield Imagery program, and increases in Projects TT-06 and TT-10 for expansion of the Affordable Rapid Response Missile Demonstrator and Advanced Logistics efforts.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-03				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Naval Warfare Technology TT-03	20.382	7.619	7.807	14.640	26.717	40.774	40.615	Continuing	Continuing

(U) **Mission Description:**

(U) The Naval Warfare Technology project develops advanced technologies for application to a broad range of naval requirements. The principal enabling technologies include: investigation into High Energy Density Materials (HEDM) for advanced explosives and propellants; innovative payload and platform concepts for expanding the envelope of operational capabilities for submersible platforms; and advanced approaches to underwater navigation.

(U) The High Energy Density Materials (HEDM) program fosters high-risk/high payoff efforts that could result in major breakthroughs in missile propellant and explosives technologies applicable to a wide variety of tactical and strategic military systems. The HEDM project will investigate the synthesis of new molecules capable of providing orders of magnitude increases in explosive and/or propulsive energy per unit weight. The stability and energy content of several such molecules have been predicted theoretically. The molecules will contain only nitrogen atoms or a very high percentage of nitrogen atoms, a situation that makes their production and use environmentally friendly. The potential benefits include: thermodynamic properties which could result in their having two-to-six times as much propulsive/explosive energy as current state-of-the-art operational materials, the "greening" of production and use, and reduction of detectability. Missile systems with size constraints could have increased range, maneuverability for flexible targeting, and/or increased kill effectiveness due to improvements in both the propellant's thrust and the warhead's lethality (per weight and volume). The program builds on theoretical work previously sponsored by other DoD organizations and provides some high risk excursions into materials which are theoretically possible but for which there is no currently known defined synthetic route.

(U) Current submarine designs are significantly limited in the quantity and types of payloads and sensors that can be accommodated; in turn, these limitations increasingly constrain the view of the future operational utility of the submarine platform. Recently completed high level studies have highlighted the critical need to address these limitations if the stealth, inherently available to submerged platforms, is to remain tactically relevant into the future. The Submarine Payloads and Sensors Program is intended to explore the possibilities that emerge when a unified set of payload and sensor concepts, operational implications, and supporting platform concepts are formulated in a balanced manner. Flexible platform concepts will be developed that support multiple payload/sensor concepts across the areas of advanced ordnance, advanced sensors, and adjuvant vehicles. To enable the breadth of thought and innovation necessary to make this effort a success, it is structured as a concept development and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-03

exploration utilizing competing multi-disciplinary design teams that cut across a spectrum of industry. Technology and programmatic roadmaps for the interlocking payload, sensor, combat system and platform concepts that evolve will be defined as part of this phase.

(U) Critical to the success of future underwater autonomous vehicles is developing accurate geolocation capability. The Underwater Navigation Program (UNP) will develop innovative technologies for precise geolocation and communication with submerged vehicles. Analogous to the Global Positioning Satellite system for above ground geolocation, the UNP will develop the technology for providing a submerged platform its location in the noisy littoral region. The data transfer will allow a receiving vessel several meter absolute accuracy while maintaining covert transmission of the information.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Project Genoa. ($ 7.016 Million)
  - Demonstrated Phase I initial operational capability of the data retrieval and visualization capability, initial operational capability of the crisis modeling capability, and began installation of modeling capability and integration with data retrieval capability at CINCPAC and DIA. Began installation and integration of advanced presentation capability. Transitioned Phase I application effort to PE 0603760E, Project CCC-01.

- High Energy Density Materials (HEDM). ($ 2.057 Million)
  - Produced new, stable, all nitrogen Ion N_5^+. One of only 3 stable all nitrogen species (N_2, discovered 1772 and N_5^-, discovered 1890).
  - Obtained spectrographic indications of N_4.
  - Continued development of synthesis pathways and theoretical chemistry support activities for High Energy Density Materials.
  - Investigated methods to scale-up successful synthetic routes to production quantities.

- Submarine Payloads and Sensors. ($ 4.365 Million)
  - Commenced concept development phase to define innovative concepts in advanced ordnance, advanced sensors, and adjuvant vehicles applicable to submarine platforms.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-03

- Selected and synthesized two cross-disciplinary technical teams from multiple organizations, including academia, government labs, small industry, large defense firms, and shipyards.
- Created two initial payload concepts together with associated mission concepts. Commenced initial concept refinement and initiated utility assessments. Continued development of additional concepts.

• Center of Excellence for Research in Ocean Sciences (CEROS). ($ 6.944 Million)
- Continued most promising ocean science efforts at the CEROS.

(U) **FY 2000 Plans:**

• High Energy Density Materials (HEDM). ($ 4.389 Million)
- Scale up synthesis of High Energy Density Materials (HEDM) to gram quantities and experimentally verify physical properties.
- Attempt synthesis of novel nitrogen molecules ($N_5^+ N_3$).

• Submarine Payloads and Sensors. ($ 3.230 Million)
- Complete concept development phase, refining and finalizing multiple payload and sensor concepts and associated mission concepts.
- Define and mature two flexible platform concepts capable of supporting multiple payload and sensor concepts.
- Identify development roadmaps and technology risks and opportunities associated with the final system and platform concepts.
- Commence risk reduction and initial prototyping of selected payload and sensor capabilities emerging from the concept development phase.

(U) **FY 2001 Plans:**

• High Energy Density Materials (HEDM). ($ 1.500 Million)
- Continue High Energy Density Materials (HEDM) development and physical property verification.
- Assess HEDM system applications.
- Complete utility assessment.
- Initiate unique tactical missile propellant formulations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-03

- Demonstrate useful combination of energetics and kinetics by nano particle bench systems.
- Downselect to one U.S. and/or Swedish source.

• Submarine Payloads and Sensors. ($ 3.307 Million)
  - Continue risk reduction and initial prototyping of selected payload and sensor capabilities emerging from the concept development phase.
  - Develop an initial prototype for submarine two-way high-bandwidth connectivity without compromise of platform stealth.

• Underwater Navigation Program (UNP). ($ 3.000 Million)
  - Initiate data collects to assess the geolocation accuracy achievable using various methods.
  - Initiate development of a low baud rate, covert transmission of the geolocation and data signal.

(U) **<u>Other Program Funding Summary Cost:</u>**

• Not Applicable.

(U) **<u>Schedule Profile:</u>**

• Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-04				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Land Systems Technology TT-04	37.204	38.290	33.321	39.854	44.831	44.688	44.529	Continuing	Continuing

(U) **Mission Description:**

(U) This project is developing technologies for enhancing the US military effectiveness and survivability in operations ranging from force-on-force conflict to military Operations-Other-Than-War (OOTW). This emphasis is on developing affordable technologies that will enhance the military's effectiveness while decreasing the exposure of US or allied forces to enemy fire. This project consists of the following main efforts: Small Low-Cost Interceptor Device (SLID); Advanced Fire Support Systems (AFSS); Counter-artillery Force Protection (CFP); Dog's Nose/Unexploded Ordnance Detection; Alternatives to Antipersonnel Landmines; Close-In Sensing; and Advanced Peacekeeping.

(U) The SLID program is developing and testing a system that protects threatened systems against missiles and projectiles with explosive warheads. The SLID system will detect, track and intercept threats such as anti-armor missiles, mortars, artillery, and top-attack sensor fused munitions at a standoff distance sufficient to render them ineffective. Applications for the SLID system include: self-defense of vehicles; defense of high value fixed sites such as command centers, hospitals, embassies, parked aircraft and radars; and, with further development, self defense of naval platforms and low-speed aircraft.

(U) The Advanced Fire Support Systems (AFSS) program will develop and test a containerized, platform independent multi-mission weapon concept. These systems will provide rapid response and lethality in packages requiring significantly fewer personnel, decreased logistical support, and lower life-cycle costs, while increasing survivability compared to current gun and missile artillery. AFSS will allow the military to capitalize on recent advances in military doctrine and infrastructure, such as the ongoing digitization of the Army. It will also allow the Army to streamline its missile acquisition plan around future common missiles. The program will develop and demonstrate highly flexible systems including a modular, multimission precision missile, a remotely commanded self-locating launcher, and a command and control system compatible with military doctrine.

(U) The Counter-artillery Force Protection (CFP) program will develop concepts for defending forces and civilian enclaves against air threats including high rate of fire missile artillery carrying submunitions. The program will explore advanced sensors, munitions and deployment concepts to counter this evolving threat. System concepts will be developed and analyzed.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-04

(U) The Dog's Nose/Unexploded Ordnance (UXO) Detection program will develop sensors for the chemically specific detection of explosives or other chemicals characteristic of land mines and/or shallowly buried UXOs. The sensors developed under this program will provide soldiers with the effectiveness of canine olfaction detection without the logistics and other constraints imposed by the use of live animals. These chemically specific sensors will work either singly or in conjunction with other technologies such as the hyperspectral mine detector, developed under the Small Unit Operations (SUO) program that exploit different physical features.

(U) DARPA is developing technologies that provide alternatives to antipersonnel landmines (APLs) under this project. The systems developed will provide our warfighter with enhanced capabilities that obviate the need for APL. Technologies include self-healing antitank (AT) minefields (that allow the protection of AT mines without the use of APL) and tags with minimally guided munitions that allow the compression of critical timelines and distances constraints imposed by conventional indirect and direct fire approaches.

(U) Close-In Sensing will develop technologies to complement our national remote sensing assets (space and airborne). The close-in sensors will exploit various phenomenologies to make robust detection, classification, and identification of mobile time-critical targets and characterization of the local radio frequency (RF) environment. The technologies developed will emphasize new approaches to detect traditionally low signal-to-noise or concealed targets.

(U) The Advanced Peacekeeping program will develop sensors and algorithms to aid US and coalition partners in peacekeeping operations. The goal of the program is to develop the technology to substantially enhance the surveillance capability of the peacekeepers, while simultaneously decreasing the number of personnel needed in potentially hostile situations. Automatic alerts, fusion of multiple sensor data, and tamper-proof systems will be developed.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Small Low-Cost Interceptor Device (SLID). ($ 4.723 Million)
  - Completed vehicle self-protection testing.
  - Transitioned ground vehicle active protection technology to Army.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-04

- Unexploded Ordnance Detection. ($ 16.401 Million)
  - Conducted field demonstration of prototype chemically specific land mine detector paired with other sensors.
  - Investigated plume tracing strategies in support of future search strategies.
  - Characterized chemical signatures of land mines in a variety of environments.
  - Conducted series of blind tests to establish current sensor capabilities.
  - Conducted prototype field demonstration in the Balkans.

- Advanced Fire Support System (AFSS). ($ 9.080 Million)
  - Continued feasibility analysis of advanced technologies for integration into platform/missile system components.
  - Developed detailed designs for the Advanced Fire Support System architecture.
  - Conducted evaluations and testing of high risk and critical components.
  - Defined system demonstration objectives.

- Alternatives to Antipersonnel Landmines. ($ 7.000 Million)
  - Investigate self-healing antitank minefields concept using modeling and simulation to assess the potential of the concept versus the current mixed antipersonnel and antitank mine system.
  - Analyze parameters, including power, communication, and attachment mechanisms, to permit tagging of individuals for tags and minimally guided munitions concept.

(U) **<u>FY 2000 Plans:</u>**

- Advanced Fire Support System (AFSS). ($ 13.190 Million)
  - Complete detail design for AFSS objective demonstration system, including launch, fire control, and each of the demonstration flight systems.
  - Develop and test component hardware and software for AFSS.
  - Continue advanced concept feasibility assessments.
  - Initiate hardware-in-the-loop tests.
  - Plan and initiate limited objective flight tests.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-04

- Counter-artillery Force Protection (CFP). ($ 1.100 Million)
  - In conjunction with the Army, define one or more system architectures, including sensors, munitions and deployment to meet the mission needs for enclave protection against missile artillery.

- Unexploded Ordnance Detection. ($ 13.350 Million)
  - Continue the development of chemical sniffers for land mine detection.
  - Reduce size, improve field response to interferents, and improve sampling system.
  - Demonstrate a condensed phase detector in the field in multiple configurations (handheld and vehicle mounted). Formalize transition with the user.

- Alternatives to Antipersonnel Landmines. ($ 10.650 Million)
  - Preliminary development of antitank minefield healing algorithms.
  - Initial demonstration of self-healing antitank mine subsystems – individual mine-surrogate mobility concepts and mine-to-mine communication methods.
  - Development and demonstration of tagging concept(s) in the laboratory.

(U) **<u>FY 2001 Plans:</u>**

- Advanced Fire Support System (AFSS). ($ 11.000 Million)
  - Continue system hardware and software development.
  - Complete limited objective flight tests.
  - Plan and initiate preparations for full system demonstrations.

- Alternatives to Antipersonnel Landmines. ($ 9.321 Million)
  - Field demonstration of self-healing antitank minefield using surrogate mines.
  - Demonstrate adhesion of tags in the field.
  - Demonstration of in-field wakeup and down-range communication with tags.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-04

- Close-in Sensing. ($ 7.000 Million)
  - Conduct radio frequency phenomenology collection.
  - Develop novel tagging technology.
  - Assess data exfiltration schemes.

- Advanced Peacekeeping. ($ 6.000 Million)
  - Develop sensor fusion algorithms.
  - Initiate automatic alert systems for peacekeeping border monitoring.
  - Assess optimal sensing modalities for application to surveillance systems.

(U) **<u>Other Program Funding Summary Cost:</u>**

- Not Applicable.

(U) **<u>Schedule Profile:</u>**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Tactical Technology TT-06	44.823	40.244	32.463	47.968	47.673	43.530	43.371	Continuing	Continuing

(U) **Mission Description:**

(U) This project focuses on five broad technology areas: (a) compact, efficient, frequency-agile, diode-pumped, solid-state lasers for infrared countermeasures, laser radar, holographic laser sensors, and high-power laser applications; (b) high performance computational algorithms for signal processing, target recognition and tracking, electromagnetic propagation, and processing of advanced materials and microelectronics; (c) precision optics components for critical DoD applications; (d) aerospace electronic warfare systems (e.g. coherent spoofers, decoys, jammers); and (e) very high speed aerospace vehicle and enabling technology (Affordable Rapid Response Missile Demonstrator). Additionally, this project will develop new tactical systems for enhanced air vehicle survivability, advanced airbreathing weapons, enabling technologies for advanced space systems, and emerging payload delivery concepts.

(U) Compact Lasers: Develop compact diode-pumped, solid-state lasers and laser-diode arrays (10x improvement in efficiency) with tens of watts average power output and wavelength tuneability in the mid infrared spectral regions to provide laser sources for infrared countermeasures against heat-seeking missiles for rotary wing/fixed wing aircraft and sea-borne platforms. Development of ultra broadband and very short pulse solid state laser technology. Explore combination of MEMS based electro-optic spatial light modulators in combination with very short pulse solid state lasers to provide a powerful new capabilities for secure communication up-links (multi-giga bits per second), aberration free 3-dimensional imaging and targeting at very long ranges (> 1000 kilometers). Innovative design concepts and system integration of microelectromechanical systems (MEMs) based spatial light modulators (SLMs), which provide a quantum leap in wavefront control, photonics and high speed electronics will be explored for an affordable and high value communications, image sensing and targeting system for use well into the 21st century.

(U) High Performance Algorithm Development and Advanced Mathematics for Microstructural Process Control: The programs will identify, develop, and demonstrate new mathematical paradigms enabling maximum performance at minimum cost in a wide variety of DoD systems applications. They look for opportunities to aggressively leverage the power of mathematical representations in order to effectively exploit the power of large-scale computational resources as they apply to specific problems of interest. The products are typically advanced algorithms and design methodologies. DARPA is pursuing the development of well-conditioned fast algorithms and strategies for the exploitation of high-dimensional data (i.e., data with a high number of degrees of freedom) in order to deal with a variety of complex military problems such as adaptive

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06

array processing for missile seekers, waveform design for spaceborne sensors and communication applications, virtual integrated prototyping of advanced material processing, efficient high fidelity scattering computations for radar cross sections, and efficient mapping of signal processing kernels onto advanced DoD hardware architectures.

(U) Precision Optics: Develop mathematical design tools and fabrication strategies for conformal sensor windows, cylinders, toroids, and diffractive optical elements. Purpose: to provide distortion-free imaging (near diffraction limit) with greater than hemispherical field-of-regard (greater than 2π steradians) and reduced aerodynamic drag (by greater than 20%) for precision strike and integrated bomb damage assessment for next-generation airborne platforms/high-speed missiles.

(U) Aerospace Electronic Warfare Systems: The Miniature Air-Launched Decoy (MALD) advanced concept technology development (ACTD) program will develop and demonstrate a small, inexpensive air-launched decoy system for Suppression of Enemy Air Defenses (SEAD). MALD will be employed to enhance the survivability of friendly aircraft by establishing air superiority through stimulating, diluting and confusing enemy Integrated Air Defense Systems (IADS). The jointly funded program by the Air Force, OSD/AT, and the Defense Advanced Research Projects Agency (DARPA) will focus on affordability. DARPA, together with the Air Force Air Combat Command only has one requirement for the program: a ceiling for the Average Unit Flyaway Price (AUFP) of $30,000 per decoy for a 3,000 unit buy. The design will leverage the Small Engine Application Program SENGAP engine program, miniaturization of electronics, and commercial equipment and process to achieve design goals. A green flag operational demonstration will be conducted to assess military utility for the $30K unit at the end of the 30-month program. Other applications of the miniature air vehicle will be explored to employ alternative electronic warfare approaches which include coherent radio frequency (RF) spoofers, and RF jammers.

(U) The Affordable Rapid Response Missile Demonstrator (ARRMD): The missile is designed to destroy high value targets in heavily protected areas at long stand-off ranges, quickly and affordably. Generally, the ARRMD program is pursuing a highspeed air breathing propulsion system that will more than triple the installed specific impulse (ISP) of current rocket power systems. The ARRMD program will prove technologies that could enhance future large scale, high speed payload delivery systems and access to space systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Compact Lasers. ($ 3.600 Million)
  - Demonstrated and delivered a brassboard high powered mid-infrared laser for ship based closed loop infrared countermeasures.
  - Demonstrated quantum cascade laser diode arrays operating at mid-infrared wavelengths.

- High Performance Algorithm Development. ($ 11.800 Million)
  - Validated prototype electromagnetic scattering models for objects in ground clutter.
  - Demonstrated data, sensor, and algorithm fusion algorithms for signal and image processing applications that exploit the feature extraction capability of wavelets.
  - Demonstrated fast algorithms for electromagnetic scattering at subwavelength scales and off rough surfaces.
  - Demonstrated feasibility of mathematical approaches to creating optimal portable applications libraries for selected computational kernels required in complex physical process simulations.

- Advanced Mathematics for Microstructural Process Control. ($ 7.139 Million)
  - Developed algorithms for fundamental chemical calculations that allow treatment of larger systems and more extended phenomena in thin film deposition.
  - Developed multiresolution homogenization techniques to reduce systems of partial differential equations to equations amenable to process optimization and design of control algorithms.
  - Validated island dynamics mathematical model and level set methods for epitaxial growth.

- Precision Optics Technology. ($ 3.580 Million)
  - Demonstrated replicated conformal missile domes.
  - Demonstrated designs for conformal missile domes.
  - Demonstrated assembly of conformal missile domes for laboratory characterization.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06	

- Miniature Air-Launched Decoy (MALD). ($ 9.772 Million)
  - Continued operational demonstrations; acquired limited flight clearance (Seek Eagle); fabricated thirty-two operational test assets and transitioned to Services.
  - Completed feasibility study to validate that a low cost interceptor derivative can be developed from a miniature air-launched decoy (MALD). Established preliminary and final design after cost and performance trades. Determined seeker design options and turbine engine integration.
  - Continued to explore other concepts for low cost MALD airframes to fill mission areas such as reconnaissance, surveillance, nuclear/biological/chemical (NBC) detection, jamming, etc.

- Affordable Rapid Response Missile Demonstrator (ARRMD). ($ 6.432 Million)
  - Completed propulsion integrated flowpath and manufacturability demonstrations.
  - Conducted vehicle force and moment testing.
  - Conducted Warfighting Analysis Lab exercises.
  - Started system preliminary design.
  - Continued exploration of supporting technologies for hypersonic missiles.
  - Refined unit cost estimate.

- Rapid Domination. ($ 0.500 Million)
  - Exploratory study to examine the concept of rapid dominance.
  - Analyze the impact of a very rapid and punitive military response to an adversary's aggression.

- Advanced Tactical Technology Concepts. ($ 2.000 Million)
  - Continued feasibility evaluation studies of emerging advanced tactical technology concepts, including high-speed launch of small payloads, autonomous maintenance capabilities, and beyond next generation space-based sensors.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06

(U) **FY 2000 Plans:**

- Compact Laser. ($ 5.200 Million)
  - Develop system applications concept and preliminary design of spatial light modulators and integrated electronics for Coherent Communications, Imaging and Targeting (CCIT).
  - Perform feasibility studies and concept development of enabling alignment and docking technologies using compact solid state laser technology for advanced space-based systems.

- Precision Optics. ($ 6.600 Million)
  - Complete assembly and test of conformal optics Stinger missile dome to quantify performance improvements.
  - Demonstrate imagery through Stinger conformal missile dome.

- High Performance Algorithm Development. ($ 8.057 Million)
  - Demonstrate utility of multiscale segmentation and registration algorithms in DoD automatic target recognition applications.
  - Develop advanced mathematical algorithms for high throughput hyperspectral infrared imaging.
  - Validate fast algorithms for electromagnetic scattering at subwavelength scales and of rough surfaces.
  - Develop codes for predicting antenna radiation patterns and scattering off of electrically large, smooth impenetrable bodies.

- Advanced Mathematics for Microstructural Process Control. ($ 2.936 Million)
  - Construct and test control/optimization codes for sputtering, evaporation and molecular beam epitaxy reactors.
  - Extend level set methodology to complex diffusion processes in thin film processing.

- Miniature Air-Launched Decoy (MALD). ($ 1.951 Million)
  - Continue operational assessment exercises with thirty-two test assets to support transition to Air Force.
  - Continue investigating advanced concept technology development (ACTD) design shortfalls and feasible redesign efforts to provide greater utility.
  - Explore other Electronic Warfare applications of stand-in air vehicles for enhanced mission performance.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-06

- Affordable Rapid Response Missile Demonstrator (ARRMD). ($ 14.000 Million)
  - Complete system preliminary design.
  - Continue propulsion ground testing of scramjet.
  - Continue exploration of supporting technologies for hypersonic missiles.
  - Continue low-cost manufacturing development and demonstration of full-scale airframe sections.
  - Complete critical design review (CDR).
  - Complete flight test plan for first flight articles.
  - Continue warfighter assessment.

- Advanced Tactical Technology Concepts. ($ 1.500 Million)
  - Explore and assess feasibility of new concepts for high-speed launch of small payloads and autonomous maintenance capabilities, exploiting next generation space-based sensors (e.g. lasers, electro optic, millimeter wave).

(U) **FY 2001 Plans:**

- Compact Lasers for Coherent Communications, Imaging and Targeting. ($ 2.000 Million)
  - Develop breadboard system with high-speed electronics integration.
  - Demonstrate greater than 1-kilometer operation for static platform and target.

- Precision Optics. ($ 1.463 Million)
  - Complete assembly and test of a conformal optics sensor system on an airborne platform to quantify performance improvements.

- High Performance Algorithm Development. ($ 9.000 Million)
  - Demonstrate feasibility and portability of optimized portable application library generation approaches for a complete signal-processing algorithm.
  - Develop and test algorithms for variable precision filters for adaptive signal processing.
  - Develop tool set implementing algorithmic, memory, and compilation models applied to a multipole test problem.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, TT-06

- Develop algorithms for predicting and optimizing antenna radiation patterns and scattering, both off of and through inhomogeneous materials and deep cavities.
- Develop computationally efficient geometric compression and registration algorithms for topography/imagery databases.

• Advanced Mathematics for Microstructural Process Control. ($ 2.000 Million)
- Validate reduced order model and algorithms for sensing and control of thin film vapor deposition processes.
- Demonstrate advanced molecular dynamics/accelerated molecular dynamics simulation techniques for the growth of multilayer materials.

• Affordable Rapid Response Missile Demonstrator (ARRMD). ($ 18.000 Million)
- Continue low-cost manufacturing development.
- Continue demonstration of full-scale airframe sections.
- Initiate fabrication of missile demonstrators.
- Continue exploration of supporting technologies for hypersonic missiles.
- Initiate flight weight engine ground demonstrators.

(U) **Other Program Funding Summary Cost:** *(In Millions)*

	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	Cost to Complete	Total Cost
Air-Launched Decoy	0.5	0.0	0.0	0.0	0.0	0.0	0.0	N/A

PE 0603750D, Advanced Concept Technology Demonstrations

(U) **Schedule Profile:**

• Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-07				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Aeronautics Technology TT-07	29.888	31.385	29.346	18.168	35.593	45.450	49.291	Continuing	Continuing

(U) **Mission Description:**

(U) Aeronautics Technology efforts will address high payoff opportunities to dramatically reduce costs associated with advanced aeronautical systems and/or provide revolutionary new system capabilities for satisfying current and projected military mission requirements.

(U) A new family of Micro-Air Vehicles (MAVs) that are at least an order of magnitude smaller than current flying systems (less than 15 cm in any dimension) will be developed and demonstrated. The capability to accomplish unique military missions as diverse as covert imaging in constrained areas, biological-chemical agent detection and characterization, remote precision mines, and urban battlefield communications enhancement, will be stressed through an examination of a variety of vehicle concepts. The resulting capability should be especially beneficial in the emerging urban warfighting environment, characterized by its complex topologies, confined spaces and areas (often internal to buildings), and high civilian concentrations. The MAV program will focus on the technologies and components required to enable flight at these small scales, including flight control, propulsion and lightweight power, navigation and communications. These will build upon and exploit numerous DARPA technology development efforts, including advanced communications and information systems, high performance computer technology, Microelectro-mechanical Systems (MEMS), advanced sensors, lightweight, efficient high density power sources, and advanced electronic packaging technologies.

(U) Micro Adaptive Flow Control (MAFC) technologies enable control of large-scale aerodynamic flows using small-scale actuators. MAFC technologies combine adaptive control strategies, distributed sensor arrays, and advanced actuator concepts like micro-scale synthetic jets, MEMS-based microactuators, pulsed-blowing and smart structures to delay or prevent fluid flow separation. MAFC technologies will be explored for a wide range of applications such as adaptive lift-on-demand for agile missiles and uninhabited tactical aircraft, lightweight gas turbine engines, and low-drag, non-intrusive methods to aerodynamically steer projectiles for extended range and precision. Advanced flow control concepts will be explored in the context of system level performance benefits and cost assessments. MAFC technology evaluations will be made under system-relevant flow conditions, and the most promising approaches will be selected for component- or system-level demonstration.

(U) The goals of the Advanced Rotorcraft Technology (ART) program are to investigate the merits of various advanced rotorcraft technologies and to conduct technology maturation efforts for two such technologies: face gear, split torque transmissions and variable diameter tiltrotors. Task 1 will design, build, and test a full scale split torque helicopter main rotor transmission based on face gear technology; a unique gear

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-07

grinding process that enables production grinding of aircraft quality face gears. Moderate scale test gears have been produced and have satisfactorily endured over 20 million cycles of load testing. The project will culminate in building and cycle testing of a small (250 SHP) transmission. Task 2 will consist of tests and experiments to investigate and mature Variable Diameter Tilt Rotor (VDTR) technology. The tilt rotor concept, as embodied in the V-22 aircraft, and as previously demonstrated in the XV-1 and XV-15 prototype aircraft, attempts to achieve the speed of a turboprop aircraft combined with the vertical takeoff and landing capability of a helicopter. This is accomplished through a mechanism that translates the vertical, lifting plane of a helicopter to the horizontal, thrusting plane of a propeller. The size of the rotor/propeller in the aforementioned applications is compromised between that desired for a lifting rotor (large diameter) and that size desired for a thrusting propeller (small diameter). The VDTR concept is an attempt to optimize both the rotor size and the propeller size by including a mechanism that extends and retracts the diameter of the rotating airfoils. While such a design is theoretically feasible and has been demonstrated in small-scale wind tunnel experiments, the concept involves considerable mechanical complexity and aerodynamic challenge. Task 3 will create a knowledge base and computer code to analyze the operational merit of advanced rotorcraft technologies such as Variable Diameter Tilt Rotor (VDTR), Face Gears, Microadaptive-Flow Control, and Smart Materials. This study will also address the relative merits of such technologies when applied in short takeoff, vertical landing (STOVL) aircraft as contrasted with vertical takeoff, vertical landing (VTOL) aircraft.

(U) Concepts for new, small-scale class of propulsion systems will be developed in the size range from 0.5 cm to 5.0 cm in diameter, with thrust levels from 10 g to 10.0 kg. They will enable future development of a new generation of very small weapons and military platforms including micro air vehicles, unmanned combat air vehicles (UCAVs), missiles and space launch vehicles. Radical new capabilities to be explored range from shirt-button-sized micro gas turbine and micro rocket engines to 5-cm scale gas turbine and pulse detonation engines (PDEs). Technologies, which may enable these systems, may be explored at larger scale to prove feasibility. Examples of new mission capabilities may include delivery of very small (200g) satellites to low earth orbit (LEO), light weight, long endurance miniature reconnaissance vehicles, and extended range small scale precision munitions. These small-scale munitions would complement emerging unmanned vehicle systems and greatly increase mission capabilities by simultaneously increasing loadout, range and precision.

(U) The Defense Advanced Research Projects Agency (DARPA), in partnership with the Office of Naval Research (ONR) and industry, formulated a program to explore two innovative new vertical take-off and landing (VTOL) concepts with the potential for significant performance improvements that would satisfy stressing mission needs. The first concept, an advanced Canard Rotor/Wing (CRW) aircraft, offers the potential for a high speed (350 knots), rapid response capability from a VTOL unmanned air vehicle (UAV) with significant range (500 nm) and stealth improvements as compared to other VTOL concepts. The second concept (A160) exploits a hingeless, rigid, rotor concept to produce a VTOL UAV with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. The VTOL UAV program transitioned to PE 0603285E in FY 2000.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-07	

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Micro Air Vehicle (MAV). ($ 12.212 Million)
  - Conducted Micro Air Vehicle (MAV) system development and fabrication. Continued exploration and demonstration of flight enabling technologies and subsystems. Initiated flight test planning for propelled rotary-wing and fixed-wing reconnaissance vehicle systems incorporating operational templates, design flight capabilities, and mission characteristics. Initiated advanced MAV concept definition.
  - Conducted assessment of small-scale air-breathing and rocket propulsion systems. Systems to be evaluated included micro-turbojet and micro-rocket engines, pulsed combustor engines, and miniature gas turbine and pulse-detonation engines. Initiated development of selected Small Scale Propulsion Systems.

- Micro Adaptive Flow Control (MAFC). ($ 5.359 Million)
  - Completed studies of MAFC feasibility for high work compressors, aerodynamically steerable munitions, advanced inlet and maneuvering technologies, and rotary and tilt wing hover vehicles.
  - Initiated development and demonstration of MAFC actuator and controller technologies for system-relevant flow conditions.

- VTOL Concepts. ($ 12.317 Million)
  - Completed detailed designs, analyses, simulations and component tests.
  - Conducted engineering, endurance and ground tests.
  - Completed wind tunnel and full scale propulsion system/rotor testing of the Canard Rotor/Wing (CRW) concept.
  - Initiated fabrication of two CRW demonstrators and three A160 demonstrators.
  - Conducted initial flight tests of A160 flight control systems on a Robinson R-22 helicopter modified for unmanned flight.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-07

(U) **<u>FY 2000 Plans</u>:**

- Micro Air Vehicle (MAV). ($ 8.438 Million)
  - Complete development of flight enabling technologies for micro air vehicles.
  - Complete flight demonstration of the hovering MAV system. Complete fabrication and begin flight test of the fixed wing MAV system.
  - Continue concept of operations evaluation for military use.
  - Incorporate autopilot into rotary wing MAV.

- Micro Adaptive Flow Control (MAFC). ($ 11.705 Million)
  - Explore new approaches to MAFC actuator and controller development.
  - Continue to assess actuator, sensor, and control system performance, control authority, bandwidth and power requirements.
  - Explore integration of MAFC technology into feasibility demonstrations for selected military applications, including high-work compressors, adaptive munitions, and fixed-and rotary wing air vehicles.

- Small Scale Propulsion Systems (SSPS). ($ 4.877 Million)
  - Complete concept evaluation of several small-scale propulsion systems, including turbines, rockets and internal combustion designs.
  - Begin detailed design of selected systems for brassboard testing.

- Advanced Rotorcraft Technology (ART). ($ 5.365 Million)
  - Conduct ART assessments and technology maturation. Conduct vehicle configuration trades and develop aircraft synthesis codes to investigate the relative merits of short takeoff, vertical-landing rotorcraft as contrasted with traditional vertical takeoff, vertical landing rotorcraft. Begin design and construction of an AH-64 size test transmission using face gear technology. Construct large scale test hardware and begin reliability testing of extension/retraction mechanisms to enable variable diameter tilt rotors.

- Advanced Aeronautic Concepts. ($ 1.000 Million)
  - Conduct technology assessments and feasibility testing of advanced aeronautic concepts, including supersonic laminar flow, air-to-air resupply and continuous aerodynamic control surfaces.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-07

(U) **FY 2001 Plans:**

- Micro Air Vehicle (MAV). ($ 0.646 Million)
  - Complete advanced MAV development including system fabrication and all flight-testing; complete military concept of operation evaluation and complete transition of MAV systems to Services.

- Micro Adaptive Flow Control (MAFC). ($ 13.000 Million)
  - Continue MAFC technology development and testing.
  - Initiate, and explore new opportunities for, MAFC technology feasibility systems demonstrations.
  - Initiate studies to integrate MAFC technologies into full-scale engine, munition and aircraft systems.

- Small Scale Propulsion Systems (SSPS). ($ 10.000 Million)
  - Complete design for propulsion systems.
  - Begin subsystem fabrication.
  - Begin subsystem checkout and brassboard demonstrations.

- Advanced Rotorcraft Technology (ART). ($ 5.700 Million)
  - Conduct rig testing of an AH-64 size face gear helicopter transmission. Complete reliability testing of extension/retraction mechanisms for variable diameter tiltrotors and begin wind tunnel testing of a 1/3-scale variable diameter tiltrotor.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-10					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Logistics Technology TT-10	20.118	10.352	15.000	24.800	24.800	24.800	24.800	Continuing	Continuing

(U) **<u>Mission Description:</u>**

(U) The Advanced Logistics Project will investigate and demonstrate technologies that will make a fundamental difference in transportation and logistics. The program will define, develop, and demonstrate fundamental enabling technologies that will permit forces and sustainment material to be deployed, tracked, refurbished, sustained, and redeployed more effectively and efficiently than ever before. Currently, this is accomplished using isolated, independent, and sometimes incompatible systems, processes and data. Therefore, the very rapid replanning and redirection necessary to support missions involving simultaneous local and major regional conflicts cannot be accomplished today. The Advanced Logistics Project will address these shortcomings and enable this significant capability to be developed. In addition, the project has enormous potential for cost savings through greatly improved management of transportation and logistics assets.

(U) This project will develop automated, multi-echelon, collaborative logistical/transportation technologies that will provide warfighters with an unprecedented capability to monitor, rapidly replan, and execute the revised logistics plan as the situation requires, even while assets are enroute to the theater. The Advanced Logistics Project will focus on the following three areas: 1) development of applications providing a technology environment that allows warfighters to rapidly understand and assess the logistics and transportation implications of a crisis situation, to generate effective plans and courses of action, to monitor a plan's execution and to use that information to re-plan; 2) automated systems that will enable significant efficiency improvements in transportation and logistics, such as improving access to data, monitoring the condition and status of shipments, personnel, inventories, logistics assets and the infrastructure, the creation of "plan sentinels" to serve as an early warning system for plan deviations, and improved theater distribution; and 3) development of a computer network infrastructure that allows distributed real-time visualization and interaction with all phases, elements and components of the military and commercial transportation infrastructure. The capabilities from these three areas will be integrated to demonstrate a prototype end-to-end system solution.

(U) The Advanced Logistics Project supports Joint Vision 2010, US Transportation Command and Defense Logistics Agency initiatives, and is coordinated with other related logistics efforts within the DoD. As these technologies mature, they will immediately transition to other joint

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-10

initiatives which include the Defense Logistics Agency's Logistics Research and Development Demonstration (PE 0603712S), the Joint Logistics Advanced Concept Technology Demonstrations (Project TT-11), and eventually to the Global Command and Control System (GCCS) and the Global Combat Support System.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Advanced Logistics Technology. ($ 20.118 Million)
  - Demonstrated an integrated environment to support the planning, execution and monitoring of a unit deployment from point of debarkation through in-theater distribution, including automated infrastructure assessment and monitoring.
  - Developed and demonstrated the ability to negotiate the exchange of information between suppliers and buyers, including rapid, flexible item and item relationship catalogs for automated sustainment processing.
  - Developed automated deviation detection and triggering of the replanning processes. Continued development of a Dynamic Critical Items List for sustainment planning and execution. Developed and demonstrated automated medium grained course of action evaluation that is linked to the war plan.

(U) **FY 2000 Plans:**

- Advanced Logistics Technology. ($ 10.352 Million)
  - Develop capability to automatically plan and schedule movements from installation to the theater of operations and integrate the resulting movement plan with operations within the theater. Demonstrate capability for users to visualize multiple facts of the transportation schedule.
  - Develop capability to dynamically manage stockage levels across multiple supply chain levels and, multiple echelons, services and agencies.
  - Develop capability to automatically notify users when projected completion of an executing task differs from planned timeline.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-10

(U) **FY 2001 Plans:**

- Advanced Logistics Technology. ($ 15.000 Million)
  - Develop capability to automatically build and compare logistics plans in support of four operational courses of action in four hours.
  - Develop capability to monitor resource information, availability, capacity, costs and to view past, present and projected logistical situations.
  - Conduct a pilot test of advanced logistic technology using the Focused Logistics Wargame 2001.
  - Develop plans for conducting follow-on pilot tests.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-11				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Joint Logistics ACTDs TT-11	9.294	9.736	10.000	10.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The Joint Logistics project is composed of two Advanced Concept Technology Demonstrations (ACTDs) that will develop and migrate interoperable web-based joint logistics decision support tools (JDSTs) to the Global Combat Support System (GCSS). The focus area for the first one, the Joint Logistics ACTD (JL ACTD), addresses Commander-in-Chief (CINC) and Service requirements to develop JDST capability in the areas of Force Capability Assessment; Logistics Support Concept Generation and Evaluation; Distribution, Materiel Management, Maintenance Analysis; and Visualization. The second ACTD, the Joint Theater Logistics ACTD (JTL ACTD) integrates and expands those and other capabilities to provide real-time management and analysis tools for logistics and operations interoperability. JDSTs will use maturing technologies to provide warfighters and logisticians with the abilities to: assess support force capabilities to perform mission tasks; develop and evaluate logistics operational support plans; monitor logistics operations; and, react to deviations from projected support. These tools will exploit near real-time logistics data sources and will be available to all users via a web-based client-server environment that complies with defense information infrastructure (DII) common operating environment (COE) architecture standards and requirements. JTL tools will provide the fusion and correlation of plans and information for critical components of theater support, sustainment, and transportation systems providing effective management, analysis, and situational awareness to the logistics commanders. JTL capabilities will include real-time interoperability between logistics and operations during all phases of planning and execution. Key data sources include Joint Total Asset Visibility (JTAV), Joint Personnel Asset Visibility (JPAV), the Global Transportation Network (GTN), the Joint Operational Planning and Execution System (JOPES), and the Global Status of Readiness and Training System (GSORTS). This project will also provide a migration path for evaluating advanced technologies that are being developed by other projects such as the DARPA Advanced Logistics Technology Project (TT-10). These ACTDs will support CINC/Joint Task Force (JTF) and Service/Agency logisticians across the entire operational spectrum -- mobilization, deployment, employment, sustainment and redeployment.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-11

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Joint Logistics ACTD. ($ 9.294 Million)
  - Developed data access and mediation capability to pull information from disparate data sources and to share data and JDST data products between applications through a common user interface.
  - Expanded tool set functionality focusing on Component and Service needs. Derived and graphically displayed planned force capability estimates for logistics units throughout the deployment sequence at specific nodes over time.
  - Determined, evaluated, displayed, and compared logistics support concepts to include unit capabilities and select supply class requirements to support one or more operational courses of action.
  - Developed the capability to track and visualize the inventory status, flow, and consumption of sustainment stocks.

(U) **FY 2000 Plans:**

- Joint Logistics ACTD. ($ 4.868 Million)
  - Expand development of Joint Decision Support Tools (JDSTs) to compare planned logistics unit support capabilities with actual capabilities at specific nodes over time.
  - Develop the capability to generate a below-the-line logistics force structure based upon the operational course of action and demonstrate the capability to provide a qualitative force capability assessment of the force structure.
  - Exercise and demonstrate advanced JDST capabilities in an expanded joint warfighting exercise.
  - Transition proven JDST capability through the Advanced Information Technology Services (AITS) Joint Program Office (JPO) into the Global Combat Support System.

- Joint Theater Logistics (JTL) ACTD. ($ 4.868 Million)
  - Develop computer-assisted capabilities to evaluate operational and logistics tasks.
  - Develop capability to calculate support unit requirements and sustainment and identify matching sources to meet mission requirements. Track the execution of that sourcing and sustainment from closure through dissemination through the theater.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Tactical Technology PE 0602702E, Project TT-11

- Incorporate logistics support capabilities and operational concepts into a single integrated view.
- Demonstrate JTL capabilities in a joint warfighting exercise.

(U) **FY 2001 Plans:**

- Joint Logistics ACTD. ($ 1.000 Million)
  - Transition Joint Decision Support Tools (JDST) capability through the Advanced Information Technology Services (AITS) Joint Program Office (JPO) into the Global Combat Support System.

- Joint Theater Logistics (JTL) ACTD. ($ 9.000 Million)
  - Expand JDST capability to integrate in-theater distribution support planning and infrastructure assessment, and to generate and compare alternative logistics support force concepts to support multiple operational courses of action.
  - Incorporate and enhance planned deviation detection technology and sentinels to compare planned resource requirements with near real-time operational logistic activity for select support items by location, provider, and intended consumer.
  - Develop capability to rapidly assess the impact of operational changes upon the logistics support structure. Develop a real-time in-theater management capability for critical resources including fuel and munitions, which integrates execution of logistics support plans with logistics and operational data feeds.
  - Develop the capability to forecast impact of deviations and alternative support concepts upon future operations.
  - Demonstrate multi-echelon interoperability and in-theater management capabilities in a joint warfighting exercise.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Integrated Command and Control Technology PE 0602708E				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	38.612	31.296	32.000	0.000	0.000	0.000	0.000	0.000	N/A
High Definition Systems IC-03	38.612	31.296	32.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because it develops the technologies for high definition displays that are important for virtually all DoD applications that involve visual and graphic information. Major components of this program include: projection, head mounted and direct view displays based on multiple technologies; development of equipment and components required to manufacture advanced display technologies; and prototyping of display systems for system evaluation. These efforts will establish a domestic technical capability for the manufacture of components necessary for military systems that capture, process, store, distribute and display high-resolution images.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishmnts:**

- High Definition Systems ($ 31.952 Million)
  - Completed development of large organic-based and inorganic display technologies and continued development of flexible substrate displays for command and control applications.
  - Continued development of equipment and components to meet display cost and performance goals. This included efforts in printing and microreplication, field emission display materials, organic light emitting materials and phosphor technology development.
  - Completed first generation integrated display systems and system prototypes for mobile applications. Continued development of large screen command and control system prototypes, to include development of a large area, high resolution.
- Flexible Emissive Displays. ($ 6.660 Million)
  - Demonstrated self-assembled fluidic transport on active matrix flexible backplanes.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Integrated Command and Control Technology PE 0602708E

(U) **FY 2000 Plans:**

- High Definition Systems. ($ 19.560 Million)
  - Develop flexible, rugged displays based on organic electroluminescence and zero-power reflective technology.
  - Develop active matrix backplanes on flexible substrates for high performance/low power rugged displays.
  - Develop enhanced maturing technologies (organic electroluminescence, field emission and flexible field substrates) to performance capabilities required for DoD applications.
  - Demonstrate/insert display technology into DoD systems to evaluate display technology.

- Flexible Emissive Displays. ($ 11.736 Million)
  - Develop higher temperature plastic substrates compatible with display manufacturing.
  - Develop light emitting materials.
  - Demonstrate emissive monochrome display.

(U) **FY 2001 Plans:**

- Flexible Emissive Displays. ($ 12.000 Million)
  - Develop reduced water and oxygen substrate permeability.
  - Develop active matrix backplane transistors.

- High Definition Systems. ($ 20.000 Million)
  - Integrate organic light emitting diodes on flexible, active matrix backplanes for increased brightness and reduced power. Integrate Field Emission and Phosphor Display Technologies.
  - Evaluate new display concepts for large, high-resolution displays.
  - Demonstrate/insert display technology into DoD systems for display evaluation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Integrated Command and Control Technology PE 0602708E

(U) **Program Change Summary:** (*In Millions*)

	FY1999	FY 2000	FY 2001
Previous President's Budget	39.607	31.296	32.000
Current Budget	38.612	31.296	32.000

(U) **Change Summary Explanation:**

FY 1999 Decrease reflects minor repricing and SBIR reprogramming.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	269.979	235.321	216.261	215.785	199.275	205.871	215.594	Continuing	Continuing
Materials Processing Technology MPT-01	165.906	116.474	123.710	130.523	125.972	122.854	122.895	Continuing	Continuing
Microelectronic Device Technologies MPT-02	83.369	92.301	71.216	70.094	63.358	73.215	83.056	Continuing	Continuing
Cryogenic Electronics MPT-06	17.731	26.546	21.335	15.168	9.945	9.802	9.643	Continuing	Continuing
Military Medical/Trauma Care Technology MPT-07	2.973	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This program element is budgeted in the Applied Research Budget Activity because its objective is to develop technology related to those materials, electronics, and biological systems that make possible a wide range of new military capabilities.

(U) The Materials Processing Technology project (MPT-01) concentrates on the development of novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components which will lower the cost, increase the performance, and enable new missions for military platforms and systems as well as to increase human performance. Areas of concentration include exploitation of emerging processing approaches to tailor the properties and performance of structural materials and devices. This emphasis includes lightweight personnel protection, mesoscale machines for miniature devices, and ultra lightweight materials. The project also focuses on smart materials, sensors and actuators, functional materials and devices, advanced magnetic materials for non-volatile, radiation hardened magnetic memories, and electroactive polymers for sensing and actuating. Other areas of concentration include new materials concepts for portable power, development of bio-interface materials and methods, energy harvesting concepts, and frequency agile materials based on ferrite and ferroelectric oxides. This project also includes a biological systems thrust. The unique characteristics of biologically derived functional materials

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E

and devices will be exploited through the understanding and control of the structure and chemistry of the interface between man-made and biotic materials. In addition, emulation and/or control of biological functionality (i.e., sensing and mobility) will be explored for enhanced DoD applications (sensor, robotic, etc.).

(U) The Microelectronics Device Technologies project (MPT-02) develops advanced electronic and optoelectronic devices, semiconductor process tools and methodologies, materials for optoelectronics and infrared devices. Areas of emphasis include high-performance analog-to-digital converters, military optical processors, novel integrated optoelectronic devices and components, high temperature electronic devices, and high power electronics. This project includes a significant effort to develop advanced materials and device technology beyond the classical scaling limits of silicon device technology.

(U) In the Cryogenic Electronics project (MPT-06), thin film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military applications. Thin-film high temperature superconducting components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance while reducing size and power requirements. Highly dependable and inexpensive cryocoolers (including thermoelectric coolers) are being developed for these applications, and expanded efforts will explore techniques to improve the performance of all solid state thermoelectric coolers as well as the overall cryogenic performance in applications ranging from communications to computing.

(U) **Program Change Summary:** (*In Millions*)	**FY1999**	**FY 2000**	**FY 2001**
Previous President's Budget	278.286	235.321	219.063
Current Budget	269.979	235.321	216.261

(U) **Change Summary Explanation:**

FY 1999 Decrease reflects IR 1415 reprogramming of the Laser Diode Array program, reprogramming to other RDT&E Defense-wide programs as part of the omnibus reprogramming, and SBIR reprogramming.

FY2000-01 Decrease reflects minor revisions of the prototype microelectronic interfaces for control of biological systems and small chemical power generation devices programs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Materials Processing Technology MPT-01	165.906	116.474	123.710	130.523	125.972	122.854	122.895	Continuing	Continuing

(U) **Mission Description:**

(U) The major goals of this project are to develop novel materials, materials processing techniques, mathematical models and fabrication strategies for advanced structural and functional materials and components which will lower the cost, increase the performance, and/or enable new missions for military platforms and systems.

(U) One important area of concentration is the exploitation of emerging processing approaches to tailor the properties and performance of structural materials and devices. Thrusts in this area include new concepts for lightweight personnel protection, ultra lightweight materials, and multi-functional materials for lowering the weight and increasing the performance of aircraft and spacecraft structures. Approaches are also being developed for reducing the risk of using new materials in defense acquisitions. Smart materials, sensors and actuators for the control of the aerodynamic and hydrodynamic behavior of military systems are being developed and demonstrated to increase performance and lower detectability of aircraft, helicopters, and submarines as well as to increase human performance. "Intrinsically smart" materials that provide self-diagnosis and/or self-repair will be developed as well.

(U) Another major thrust is the development of functional materials and devices. This includes advanced magnetic materials for high sensitivity, magnetic field sensors; non-volatile, radiation hardened magnetic memories with very high density, short access time, infinite cycleability and low power; and electroactive polymers for sensing, actuating, and analog processing. Frequency-agile materials based on ferrite and ferroelectric oxides are being developed for tuned filters, oscillators, and antennas. New permanent magnetic materials with significantly higher magnetic strength and higher operating temperature for motors, generators, flywheels, bearings, and actuators are also being explored.

(U) The mesoscopic size range ("sugar cube to fist") offers significant advantages in devices for defense. Efforts include mesopumps for battlefield sensors and mesocoolers for the individual soldier. Technology for the mask-less, direct-write of mesoscopic integrated conformal electronics will enable the three-dimensional integration of both active and passive components, significantly reducing the size, weight, and cost of integrated electronics functions (circuits, batteries, antennae, etc.).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

(U) New materials and concepts for increasing the availability of portable power to the soldier are being investigated, as are approaches for deriving power for soldiers and sensors from the environment. These efforts will contribute to the design and fabrication of biohybrid devices. Structure and function emulated from biological systems will result in new biomimetic systems which capture unique locomotion and sensing schemes. Finally, the unique characteristics of biologically derived functional materials and devices will be exploited through the understanding, control, and emulation of the structure and chemistry of the interface between man-made and biotic materials.

(U) <u>Program Accomplishments and Plans:</u>

(U) <u>FY 1999 Accomplishments:</u>

- Structural Materials and Devices. ($ 32.500 Million)
  - Fabricated and tested materials and materials systems concepts designed to significantly improve personnel protection performance (e.g., >100 percent improvement from current capabilities for 7.62 mm armor piercing round), dramatically increasing protection for the individual soldier.
  - Demonstrated solid freeform fabrication of titanium forging blanks.
  - Demonstrated spray forming of superalloy forging billets.
  - Demonstrated the use of solid freeform fabrication to upgrade distressed turbine vanes in man-rated gas turbine engines with ceramic composite components of high reliability.
  - Demonstrated initial feasibility, fabrication and performance of prototype mesoscale machines and components (e.g., miniature air blower, microcooler, meso pump, water purifier, etc.).
  - Demonstrated capability of sub-scale mesoscale pumping chambers to meet full-scale air blower design requirements.

- Smart Materials and Actuators. ($ 28.516 Million)
  - Demonstrated vortex wake reduction for submarines using smart materials.
  - Evaluated submarine acoustic noise reduction using smart materials pads and tiles.
  - Demonstrated a full-scale shape adaptive fighter inlet.
  - Established growth conditions for large piezoelectric single crystals from flux using both open and closed crucible techniques.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

- Evaluated the impact of piezoelectric single crystals on Navy low-frequency surveillance sonar, mid-frequency navigation/tactical sonar, and high-frequency weapons guidance sonar.

• Functional Materials and Devices. ($ 59.840 Million)
  - Demonstrated high speed, radiation hardened, medium density, and non-volatile magnetic memory utilizing magnetic multilayers; developed methods for controlling the microstructure of these giant magneto-resistive (GMR) films during growth.
  - Demonstrated a very high sensitivity magnetometer and gradiometer for localization of magnetic anomalies.
  - Demonstrated a permanent magnet material with a 20 percent higher strength (energy product).
  - Expanded the use of solid freeform fabrication to demonstrate a new process for the fabrication of silicon carbide devices and simple electronic component parts using rapid tool-less deposition processes.
  - Completed polymer development for infrared artificial dielectrics (IRADs).
  - Demonstrated the actuation capability of polymeric muscles.
  - Demonstrated a loss tangent less than 0.002 in hybrid ferrite/ferroelectric frequency agile filters.
  - Demonstrated a voltage-controlled oscillator (VCO) with an octave tuning range and low loss.
  - Demonstrated enhanced biological responses (molecular, cellular and organismal) at modified material interfaces. Identified approaches for the neurological control and behavior of simple biological systems through biomaterial development.
  - Demonstrated actuator materials and bioinspired control strategies for biomimetic locomotion systems; developed biomimetic systems that incorporate extremophile strategies for enhanced stability and performance in the environmental extremes required by the DoD.

• Energy and Environmental Sciences. ($ 24.600 Million)
  - Designed a low temperature, packaged direct oxidation fuel cell for soldier applications.
  - Demonstrated alternative energy sources (including thermal energy conversion) for soldier microclimate cooling and for portable battery chargers.
  - Demonstrated energy harvesting concepts from ambient sources for unattended sensor applications.
  - Investigated fate and transport of chemicals in soil as well as chemotaxis schemes for localization of sources.
  - Demonstrated approaches to augment portable power sources by recovering energy from human activity.
  - Completed demonstration and insertion of advanced erosion/corrosion resistant and anti-fouling thin film coatings in military systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

- Seamless High Off-Chip Connectivity (SHOCC). ($ 5.000 Million)
  - Demonstrated the SHOCC concept in an advanced signal processor device in which a flip-chip digital signal processor is bump-bonded to an interposer layer.

- Laser Diode Array. ($ 3.000 Million)
  - Developed laser diode bar mounting techniques in laser diode arrays.

- Nanophase Magnetic Materials. ($ 7.000 Million)
  - Continued research at the Advanced Materials Research Institute to demonstrate nanostructured magnetic materials for enhanced density magnetic media.

- Strategic Materials Manufacturing. ($ 2.000 Million)
  - Developed new manufacturing approaches for cutting tools for Defense strategic materials.

- Polymer Materials. ($ 4.000 Million)
  - Continued development of polymer materials and processing.

(U) **FY 2000 Plans:**

- Structural Materials and Devices. ($ 20.100 Million)
  - Integrate material concepts and materials systems into ultra-lightweight armor providing 100 percent improvement in personnel protection for the soldier.
  - Develop analytical, experimental, and simulation technologies for predicting the cost, performance, and life of advanced materials, decreasing the risk of and accelerating the time for insertion of new materials in Defense acquisitions.
  - Investigate concepts for the use of multifunctional materials in Defense applications (e.g., blast protection, thermal control) based on successes in ultra-lightweight metals and other structural materials programs.
  - Develop approaches for rapid design, optimization and assembly of small structures and devices based on solid freeform and rapid prototyping technologies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

- Mesoscopic Structures and Devices. ($ 8.774 Million)
  - Demonstrate the operation of a mesoscopic pump array with flow rates over 5 liters/min. in one cubic inch.
  - Build and test an individual integrated mesoscopic cooler.
  - Demonstrate a mesoscopic vacuum pump integrated with a mass spectrometer on a chip.
  - Demonstrate the ability to directly write active and passive electronic materials and components at the mesoscale.

- Smart Materials and Actuators. ($ 25.000 Million)
  - Demonstrate improvements in aerodynamic performance through wind tunnel testing of wings with adaptive leading and trailing edge control surfaces.
  - Develop a "smart skin" for the reduction of self-noise and radiated noise in torpedoes.
  - Explore novel actuator schemes for enhancing the performance of soldiers or devices.
  - Demonstrate techniques to grow large (>3 cm) single crystals of relaxor piezoelectrics.
  - Demonstrate the performance of single crystal piezoelectrics in broadband ultrasonic imaging transducers.

- Functional Materials and Devices. ($ 44.000 Million)
  - Demonstrate very fast (<20 nsec access time), high density, radiation hardened magnetic memory circuits utilizing both giant magneto-resistance (GMR) multilayers and spin dependent tunneling devices; fully understand the micromagnetics of magnetic domain rotation in these devices.
  - Demonstrate very small, low power, high sensitivity magnetic gradiometers for the localization and identification of small ferrous objects.
  - Demonstrate permanent magnet materials with 50 percent higher magnetic strength (energy product) and the ability to preserve magnetic properties to temperatures over 250 C.
  - Demonstrate a loss tangent less than 0.001 in hybrid ferroelectric/ferrite devices.
  - Demonstrate a broadband 360-degree phase shifter with very low loss for antenna feed applications.
  - Demonstrate polymeric actuators that emulate the mechanical response and performance of human muscles.
  - Demonstrate green light-emitting diodes (LEDs) fabricated from electroactive polymers, with a half-life >5,000 hours; demonstrate blue and red LEDs with >1,000 hours half-life.
  - Select appropriate polymeric materials with electronic characteristics for field-effect transistor (FET) development.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

- – Demonstrate growth of AlGaSb-InAs thin films on GaAs substrates using the lateral epitaxial overgrowth technique.
- – Demonstrate lattice mismatched epitaxial growth of dislocation free compound semiconductors using strain-absorbing layers.

• Bioinspired Materials and Devices. ($ 2.400 Million)
- – Explore sensormotory and navigational control schemes for biological systems through microelectronic interfaces.
- – Evaluate chemical, visual, and acoustic cues used by biological systems for controlled locomotion, behavior, and distribution.
- – Evaluate computational neuromechanics and biomechanics of locomotion in horizontal and vertical legged locomotion and microflight.

• Advanced Energy Technologies. ($ 16.200 Million)
- – Demonstrate and field test compact portable power systems in soldier applications.
- – Develop high efficiency direct thermal to electric energy conversion.
- – Demonstrate (in the laboratory) power generation from the environment capable of operating unattended ground sensors.
- – Investigate novel concepts for small-scale, near ambient temperature, chemical power generation.

(U) **FY 2001 Plans:**

• Structural Materials and Devices. ($ 20.200 Million)
- – Demonstrate ultra-lightweight armor with 100 percent improvement over current materials and begin transition of manufacturing/design capabilities to the Army.
- – Demonstrate the use of multifunctional materials to provide significant improvement in the capabilities of defense systems by providing additional functions (e.g., self-healing, thermal control, blast protection, power) to load bearing structure.
- – Continue the optimization of analytical, experimental, and simulation technologies for predicting the properties of advanced materials.
- – Select specific material(s) of high value to a DoD system for demonstration of accelerated insertion concepts.

• Mesoscopic Structures and Devices. ($ 12.200 Million)
- – Demonstrate mesoscopic compressor operation that can work against 4 times atmospheric pressure.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

- Demonstrate fully functional integrated mesoscopic coolers that exhibit a coefficient of performance >4 and have 1/3 the weight of the smallest normal-scale coolers.
- Demonstrate that direct-write mesoscale active and passive components have functionality close to discrete surface mount components.
- Demonstrate the ability to direct-write mesoscale passive components (resistors, capacitors), batteries and patch antennas on conformal surfaces.

• Smart Materials and Actuators. ($ 25.500 Million)
  - Complete wind tunnel test verification of an active aircraft engine inlet enabling a 20 percent increase in aircraft mission radius compared to a conventional fixed geometry inlet design.
  - Complete water tunnel test of a subscale submarine propulsor with active control to reduce acoustic radiation levels.
  - Complete flight test of a rotorcraft with blades containing integral actuators and flaps for control of noise and vibration.
  - Explore techniques that use the intrinsic response of a material to its operating environment to provide diagnosis of the performance life of the material.
  - Develop approaches for integrating actuators, power systems and control methods to affect lightweight, energy efficient actuators for enhancing the performance of soldiers or devices.
  - Demonstrate methods to fabricate multilayer actuators made from single crystals of relaxor piezoelectrics.
  - Demonstrate the performance of single crystal piezoelectrics in an advanced Navy sonar transducer.

• Functional Materials and Devices. ($ 44.712 Million)
  - Demonstrate a prototype, very high effective density (>16 Mbit), high speed (<10 nsec access time) magnetic memory circuit based on giant magneto-resistance (GMR) or spin-dependent tunneling utilizing very low power and low voltage (<2.5 volts).
  - Design a prototype slotless integral motor/pump with advanced magnetic materials for improved efficiency and performance.
  - Demonstrate a steerable ferroelectric lens for phased array radar.
  - Demonstrate a conformal, frequency agile antenna that is 100x smaller than conventional technology.
  - Demonstrate electronic mobility of $>10^{-4}$ cm^2/Vs in electroactive polymeric materials.
  - Demonstrate advantages of polymer based actuators in specific Defense applications (e.g., robotics, sonar).
  - Demonstrate the use of electroactive polymers as thin film spatial filters for quasi-real-time multispectral image analysis for enhancing target detectability.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-01

- Fabricate a preamplifier for a millimeter wave radar front end with a 4-dB improvement in sensitivity using lateral epitaxial overgrowth fabrication capabilities.
- Demonstrate the use of twist bonded substrates for integration of an infrared focal plane with integrated read-out electronics.
- Demonstrate scale-up capability for single crystal growth utilizing x-ray interference patterns to template crystal growth.

• Bioinspired Materials and Devices. ($ 6.098 Million)
  - Identify candidates for advanced sensor systems that incorporate biologically inspired concepts including self-calibration, self-healing, variable temperature operation, functional responsiveness, and mobility.
  - Construct prototype microelectronic interfaces for control of biological systems.
  - Demonstrate millimeter to centimer scale actuators that emulate the legged and winged locomotion of biological systems.

• Advanced Energy Technologies. ($ 15.000 Million)
  - Demonstrate energy harvesting from the environment for unattended sensor and soldier applications.
  - Demonstrate (in the laboratory) high efficiency direct thermal to electric energy conversion operating on a hydrocarbon fuel.
  - Develop specific approaches for small, chemical power generation that operates at near ambient temperatures.
  - Investigate novel ultra-high energy density power source concepts.

(U) **Other Program Funding Summary Cost:**

• Not Applicable.

(U) **Schedule Profile:**

• Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02

COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Microelectronic Device Technologies MPT-02	83.369	92.301	71.216	70.094	63.358	73.215	83.056	Continuing	Continuing

(U) **Mission Description:**

(U) This project develops advanced electronic and optoelectronic devices, semiconductor process tools and methodologies, materials for optoelectronics, and infrared devices. Areas of emphasis include high performance analog-to-digital (A/D) converters, military optical processors, novel integrated optoelectronic devices and components, high temperature electronic devices, and high power electronics. In addition, this project develops and demonstrates advanced microelectronics technology for DoD critical needs including digital radar receivers and acoustic-electronic components. Technologies developed in this project are performance driven and exceed commercial capabilities. This project includes a significant effort to develop advanced material and device technology beyond the classical scaling limits of silicon device technology.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Advanced Microelectronics (AME). ($ 7.741 Million)
  - Characterized candidate 25-nm transistors $(150nm)^2$ total area and established process sequence for chip for proof-of-principle demonstration.
- Digital Receiver Technology. ($ 10.466 Million)
  - Developed advanced digital processor components.
- High Power Electronics. ($ 1.800 Million)
  - Continued development of SiC materials for High Power Electronic Switching Devices increasing wafer diameter and lowering defect density. Explored new concepts for integration of multiple materials on silicon chips.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02

- High Powered Solid State Electronics. ($ 6.664 Million)
  - Demonstrated high current density (>100 A/cm^2) 1000-V-class SiC high power switch; demonstrated high-temperature (>250 C) operation of a 1000-V-class switch.
- Very Large Scale Integrated (VLSI) Photonics. ($ 19.033 Million)
  - Demonstrated integrated 8x8 VLSI photonics chip (laser, detector and electronics) and optoelectronic modeling tools compatible with electronic CAD tools and demonstrated the feasibility of using molecular self-assembly techniques to position optoelectronic devices with high precision on silicon circuits.
- Sonoelectronics. ($ 7.616 Million)
  - Carried out full sonoelectronic integration, combining surface micromachined transducer arrays, low-noise Complementary Metal Oxide Semiconductor (CMOS) electronic readout, acoustic lens and packaging technology, and low-power display technology to fabricate high resolution underwater imager.
- HERETIC. ($ 4.749 Million)
  - Demonstrated heterostructure integrated thermoelectric (TE) or thermionic devices having the same heat-removal capacity as the best commercial off-the-shelf (COTS) TE coolers; fabricated micro-jets, micro-nozzles or micro-thermionic emitters capable of monolithic integration with Si circuits.
- Materials Integration. ($ 3.592 Million)
  - Explored new concepts in technology for integrating various materials on substrates.
- Reconfigurable Aperture (RECAP). ($ 9.448 Million)
  - Twelve contracts awarded to address specific core technologies including MEMS, photonic bandgap materials, multi-layer substrate integration, optical control circuits, frequency selective materials and artificial magnetic conductors. Design and analysis initiated.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02

- 3-D Microelectronics. ($ 5.500 Million)
  - Continued development of key technologies behind a packaging concept that uses a stacked MCM approach to reduce interconnect length and increase physical connectivity between layers of electronics.

- MEMS Deep Etching. ($ 6.760 Million)
  - Initiated MEMS Deep Etching project in conjunction with Army Research Laboratory.

(U) **<u>FY 2000 Plans:</u>**

- Reconfigurable Aperture (RECAP). ($ 15.648 Million)
  - Design, model, and fabricate MEMS elements. Develop and demonstrate integration technologies including advanced control techniques, broadband tunable ground planes, and multilayer packaging technologies.

- Digital Receiver Technology. ($ 3.956 Million)
  - Demonstrate a very high performance analog-to-digital (A/D) converter with 14 effective bits, 60 MHz instantaneous bandwidth, and >86 dB spurious free dynamic range (SFDR) in FY00 with potential for multiple military applications.

- High-powered Solid State Electronics. ($ 2.934 Million)
  - Demonstrate high-current density (>100 A/cm^2) 2500-V class switch from SiC; demonstrate 2500-V rectifier diode from GaN.

- Sonoelectronics. ($ 9.705 Million)
  - Complete sonoelectronic camera prototype fabrication, and carry out laboratory characterization and test-tank demonstration. Carry out sonoelectronic integration for air-couple arrays including acoustic matching and electronic read-out technologies.

- HERETIC. ($ 9.780 Million)
  - Complete integration of HIT device arrays with bias and control circuitry on GaAs substrates; complete integration of micro-jet, micro-nozzle or micro-thermionic arrays with bias and control circuitry over Si substrates.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02

- Advanced Microelectronics (AME). ($ 9.786 Million)
  - Demonstrate circuit and modeling of a full-scale system (e.g. image processing system) featuring terascaled-compatible devices and associate technology far beyond the existing industry roadmap.

- VLSI Photonics. ($ 19.560 Million)
  - Develop VLSI heterogeneous integration technology and integrate micro-opto-mechanical components with VLSI chips; develop system-level CAD tools.

- Materials Integration on Silicon. ($ 10.987 Million)
  - Initiate an integration program that develops a tool kit of materials and processes for integration of multiple materials onto a single silicon substrate.

- Photonic Wavelength and Spatial Signal Processing (Photonic WASSP). ($ 9.945 Million)
  - Initiate program to begin a major development in photonics, using both wavelengths – wavelength optics – as well as spatial attributes of light – bulk optics.

(U) **FY 2001 Plans:**

- Reconfigurable Aperture (RECAP). ($ 19.000 Million)
  - Integrate and assemble component technologies to subarrays. Demonstrate reproduceable fabrication and reconfigurability. Continue successful core technologies and initiate contracts for integrated system applications demonstrations.

- Digital Receiver Technology. ($ 4.000 Million)
  - Develop 16 Effective bit, 100 MHz bandwidth A/D converter.

- Sonoelectronics. ($ 6.000 Million)
  - Integrate advanced transducer and acoustic-lens technologies into prototype camera. Demonstrate lab-proven imager in very-shallow-water (VSW) field setting. Carry out laboratory demonstration of an air-coupled array as an electronically steered microphone array.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-02

- HERETIC. ($ 10.000 Million)
  - Demonstrate HIT devices on GaAs having twice the specific heat-removal capacity as the best COTS TE coolers; demonstrate micro-jets, micro-nozzles, or micro-thermionic emitters on Si having 5 times the heat-removal capacity as the best convective air or liquid cooling systems.

- VLSI Photonics. ($ 12.216 Million)
  - Demonstrate SAR processor using VLSI Photonics technologies; showcase reconfigurable cross-connect switching. Demonstrate rapid parallel access to memory using optical interconnection.

- Material Integration On Silicon. ($ 9.000 Million)
  - Continue integration of new material and processes into a single silicon substrate that will drive system performance. Demonstrate logic circuits and power amplifiers on silicon.

- Photonic Wavelength and Spatial Signal Processing (Photonic WASSP). ($ 11.000 Million)
  - Continue component development, integration, algorithms, architectures and sub-system functionality demonstrations.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research					R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-06				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Cryogenic Electronics MPT-06	17.731	26.546	21.335	15.168	9.945	9.802	9.643	Continuing	Continuing

(U) **Mission Description:**

(U) Thin film electromagnetic materials have reached a stage of development where specific applications can be identified in electronic devices and circuitry for military systems. Films may be deposited and patterned to form electromagnetic components in ways that are similar to, and compatible with, the processes of conventional semiconductor manufacturing. Such electromagnetic components, as well as complementary metal oxide semiconductors (CMOS), work best at lower temperatures, so that cryogenic packaging generally will be required for optimum performance. Thin-film high temperature superconducting (HTS) components packaged with cryogenic devices are being applied to radars, electronic warfare suites, and communications systems to enhance performance by more than an order of magnitude while reducing size and power requirements. Particular demonstrations include upgraded ship-defense radar (SPQ-9B) with 100X greater detectability of missiles in littoral clutter and communications receivers with greater immunity to interference. Highly dependable and inexpensive cryocoolers are also being developed for these applications. These latter development efforts include the exploration of techniques to improve the performance of solid-state thermoelectric materials and devices in applications ranging from communications to power generation.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Cryogenics Technologies. ($ 8.093 Million)
  - Inserted cryogenic packages in communication transceivers that mitigate electromagnetic interference effects.
  - Demonstrated SIGINT (Signals Intelligence) applications in aircraft and on the ground, showing range enhancement due to cryogenics.

- Multitechnology Integration in Mixed-Mode Electronics (MIME). ($ 4.960 Million)
  - Demonstrated a tunable bandpass filter in the 800-900 MHz range, using a combination of high-temperature superconductivity and micro-electro-mechanical technologies, with Q>5,000 and frequency shift >5%, retaining sensitivity enhancement with tunability.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-06

- Thermoelectric Materials and Devices. ($ 4.678 Million)
  - Demonstrated thermoelectric cooling materials that can achieve 100°C cooling in three stages or less as compared to the current seven stages.
  - Demonstrated potential benefit of efficient power generation from thermoelectric devices operating at high temperature (>500°C).

(U) **FY 2000 Plans:**

- Cryogenics Technologies. ($ 22.233 Million)
  - Develop devices and components, based upon superconducting and other electromagnetic materials that in a cryogenic environment would provide a 5-10X-range improvement over conventional means for detection of low-level signals.
  - Complete adaptation of cryocoolers in microelectronics packages for communications transceivers.
  - Expand efforts in mixed-mode electronics technology development to include tunable high temperature superconducting filters that preserve high-Q, with 10% tunability.

- Thermoelectric Materials and Devices. ($ 4.313 Million)
  - Demonstrate thermoelectric cooling materials that can achieve 100°C cooling in two stages or less.
  - Demonstrate a thermoelectric converter with a factor of two improvements in power generation per unit size.

(U) **FY 2001 Plans:**

- Cryogenics Technologies. ($ 21.335 Million)
  - Fabricate a cryogenic module, operating as a front-end pre-selector, to enhance the sensitivity of a receiver to detect low-level emitters in the presence of multiple interferors.
  - Design a complete cryogenic receiver module, incorporating tunable high temperature superconducting (HTS) antenna/pre-selector and digital microelectronics (with HTS embedded passives), displaying unsurpassed sensitivity and interference rejection.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-06

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research				R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-07				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Military Medical/Trauma Care Technology MPT-07	2.973	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The DARPA Combat Casualty Care program had two major segments: (1) Advanced Biomedical Technology (ABT) and (2) Ultrasonic Diagnostic Imaging. The ABT segment, completed in FY 1998, exploited DARPA's unique leadership role in the electronics and information sciences to project advanced medical care into the far-forward battlefield area to effect early, successful clinical intervention. The Ultrasonic Diagnostic Imaging segment developed high-fidelity diagnostic imaging primarily for the far-forward battlefield environment. The emphasis of this effort was on enhancing and miniaturizing biomedical applications of ultrasound. The program completed in FY 1999.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- 3-D Ultrasound Technologies. ($ 2.973 Million)
  - Completed ultrasound enhancements for scattering, deaberration, and beam forming; demonstrated resulting system; and transitioned to the Services.

(U) **FY 2000 Plans:**

- Not Applicable.

(U) **FY 2001 Plans:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA2 Applied Research	R-1 ITEM NOMENCLATURE Materials and Electronics Technology PE 0602712E, Project MPT-07

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E, R-1 #32				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	0.000	19.664	24.000	28.000	30.000	20.986	19.986	Continuing	Continuing
Advanced Aerospace Systems ASP-01	0.000	19.664	24.000	28.000	30.000	20.986	19.986	Continuing	Continuing

(U) **Mission Description:**

(U) The Advanced Aerospace Systems program element (PE) is budgeted in the Advanced Technology Development Budget Activity because it will address high payoff opportunities to dramatically reduce costs associated with advanced aeronautical systems or provide revolutionary new system capabilities for satisfying current and projected military mission requirements. Research and development of integrated system concepts, as well as enabling vehicle subsystems will be conducted. This new PE has been created to satisfy an Agency requirement for a dedicated host for aerospace research that has progressed beyond the applied research stage and no longer belongs in the 6.2 based Tactical Technology PE. Two of the three initial programs in FY 2000 are outgrowths of Tactical Technology efforts that were previously budgeted in PE0602702E.

(U) The Supersonic Miniature Air-Launched Interceptor (MALI) program will demonstrate an inexpensive supersonic air platform with a low cost uncooled infrared (IR) sensor to provide cruise missile defense by exploiting large rear aspect IR signatures and overtaking incoming missiles from the rear. As a further cost reduction, the program will leverage off the existing miniature air-launched decoy (MALD) program's technology and off board surveillance and tracking sensors to provide tail-on missile end game opportunities (MALD is funded in FY 1999 from Project TT-06, PE 0602702E). An advanced unmanned air vehicle avionics development effort will be incorporated into the MALI core program due to the required data transmit/receive configuration of the interceptor mission.

(U) The Navy and the Marine Corps have a need for affordable, survivable, vertical take-off and landing (VTOL) unmanned air vehicles (UAV) to support dispersed units in littoral and urban areas. The Defense Advanced Research Projects Agency (DARPA), in partnership with the Office of Naval Research (ONR) and industry, have formulated the Advanced Air Vehicle program (AAV) to explore two innovative vertical take-off and landing (VTOL) concepts with the potential for significant performance improvements that would satisfy stressing mission needs. The first, an advanced Canard Rotor/Wing (CRW) aircraft, offers the potential for a high speed (350 knots), rapid response capability from a VTOL unmanned air vehicle (UAV) with significant range (500 nm) and stealth improvements as compared to other VTOL concepts. Detailed design, fabrication and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)		DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E	

flight test of this scaled vehicle concept will be conducted to validate the command and control, stability and control system and aerodynamic performance required for vertical take-off, landing (VTOL) and hover via a rotating center wing which is stopped and locked in place for efficient high speed cruise. The second concept (A160), will exploit a hingeless, rigid, rotor concept to produce a VTOL unmanned air vehicle (UAV) with very low disk loading and rotor tip speeds resulting in an efficient low power loiter and high endurance system. This unique concept offers the potential for significant increases in VTOL UAV range (2000-3000 nm) and endurance (>24-48 hours). Detailed design, fabrication and testing of this concept will be conducted to establish its reliability, maintainability and performance.

(U) The Orbital Express Space Operations Architecture program will demonstrate the capability to service, upgrade and reconfigure satellites on orbit. An important element of the program is the enabling nature of such capability for new space missions and its potential to reduce space program costs through spacecraft life extension (Pre Planned Product Improvement P3I), like is done today with aircraft. Phase I program elements will address hardware concepts and designs (expandable replacement, subsystem replacement/upgrade, reconfiguration); software and sensors for robotic space operations; and the use of water as an innovative and potentially cost saving spacecraft fuel infrastructure. Given the demonstration of a technically achievable approach from Phase I, Phase II will develop needed technologies and demonstrate the concept on orbit. The FY 2001 funding of this program's technology development is exploiting the development of advanced tactical technology concepts and compact laser technologies (approximately $5 million) funded under PE 0602702E, Project TT-06 in FY 2000 as well as efforts in Project ASP-01.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Not Applicable.

(U) **FY 2000Plans:**

- Advanced Air Vehicle (AAV). ($ 9.505 Million)
  - Continue fabrication and conduct hardware in the loop and ground testing of Canard Rotor/Wing (CRW).
  - Complete fabrication of two A160 prototypes and conduct ground and flight tests.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E

- Supersonic Miniature Air-Launched Interceptor (MALI). ($ 6.859 Million)
  - Conduct engine and low cost miniature sensor and advanced payload testing.
  - Fabricate, assemble and conduct ground and early risk reduction testing of air vehicle.
  - Initiate detail test planning for flight demonstration of interceptor and collaborative formation mission.
  - Explore other concepts for low cost MALI/MALD airframes to fill mission areas such as reconnaissance, surveillance, nuclear/biological/chemical (NBC) detection, jamming, etc.

- Orbital Express Space Operations Architecture. ($ 3.300 Million)
  - Conduct assessment and affordability analysis of potential guidance, propulsion, docking and sensor concepts; and preliminary design of systems, including the cooperative target spacecraft and robotic transfer vehicle; develop test plan for launch demonstration.
  - Conduct preliminary design for fueling and capture concepts that enable robotic on-orbit servicing and upgrade.
  - Conduct test for robotic servicing components.

(U) **FY 2001Plans:**

- Supersonic Miniature Air-Launched Interceptor (MALI). ($ 7.000 Million)
  - Continue air vehicle fabrication, assembly and conduct ground testing.
  - Demonstrate airborne inter-vehicle communications, mission processing and execution.
  - Perform supersonic engine flight verification and seeker/advanced payload verification.
  - Conduct Flight Demonstration of supersonic vehicle interceptor and collaborative formation flying mission.
  - Continue to explore other concepts for low cost MALI/MALD airframes to fill mission areas such as reconnaissance, surveillance, nuclear/biological/chemical (NBC) detection, jamming, etc.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E

- Orbital Express Space Operations Architecture. ($ 17.000 Million)
  - Perform detailed design and conduct preliminary design review robotic transfer vehicle and target spacecraft.
  - Conduct critical component development and ground testing.
  - Complete development of modularized standardized spacecraft architecture.
  - Develop high efficiency propulsion motors for inter-space transport.

(U) **Program Change Summary** *(In Millions)*

	FY1999	FY 2000	FY 2001
Previous President's Budget	0.000	19.664	19.000
Current Budget	0.000	19.664	24.000

(U) **Change Summary Explanation:**

FY 2001 Increases reflects expansion of the Orbital Express Operations Architecture effort.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Oct 99	Canard Rotor/Wing (CRW) Critical Design Review.
Nov 99	Conduct Supersonic Miniature Air-Launched Interceptor (MALI) Requirements Definition.
Jan 00	Flight test A160 air vehicle.
Jan 00	Select preferred Orbital Express system operating description.
Jan 00	Perform Miniature Air-Launched Interceptor (MALI) Critical Design Review after conducting performance trades.
Jan 00	Conduct Preliminary Design Review (PDR) for Orbital Express Space Operations System.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Aerospace Systems PE 0603285E

Feb 00	Canard Rotor/Wing Detailed Design Review.
Jun 00	Complete Canard Rotor/Wing (CRW) ground testing.
Aug 00	Complete initial A160 flight control system testbed flights.
Aug 00	Complete ASTRO Flight Test Demonstration Plan.
Sep 00	Conduct Orbital Express Space Operations Architecture Proof-of-Concept demonstration.
Nov 00	MALI demonstration of higher thrust output of TJ-50 derivative.
Mar 01	Conduct Preliminary Design Review (PDR) for Orbital Express Space Operations Architecture System.
Mar 01	Demonstrate MALI low cost seeker requirements.
Jun 01	MALI Supersonic Flight Demo with seeker.
Sep 01	Complete Orbital Express Critical Component Demonstration.
Sep 01	Complete ground test of high efficiency propulsion system.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)					DATE September 1999				
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	259.577	246.023	193.000	194.834	187.767	164.354	147.954	Continuing	Continuing
Uncooled Integrated Sensors MT-03	12.473	10.791	12.000	7.000	0.000	0.000	0.000	0.000	N/A
Electronic Module Technology MT-04	60.755	56.686	35.650	35.149	39.667	38.029	34.829	Continuing	Continuing
Tactical Information Systems MT-05	32.112	20.205	15.600	23.100	16.000	0.000	0.000	0.000	N/A
Microwave and Analog Front End Technology MT-06	3.809	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Centers of Excellence MT-07	6.062	4.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Manufacturing Technology Applications MT-08	20.385	21.846	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Advanced Lithography MT-10	48.026	39.000	44.900	45.000	45.000	45.000	45.000	Continuing	Continuing
Microelectromechanical Systems (MEMS) MT-12	75.955	71.498	42.350	38.575	37.100	31.325	18.125	Continuing	Continuing
Mixed Technology Integration MT-15	0.000	21.997	42.500	46.010	50.000	50.000	50.000	Continuing	Continuing

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E

(U) Mission Description:

(U) The Advanced Electronics Technology program element is budgeted in the Advanced Technology Development Budget Activity because it seeks to design and demonstrate state-of-the-art manufacturing and process technologies for the production of various electronics and microelectronic devices, sensor systems, actuators and gear drives that have both commercial and military applications. Introduction of advanced product design capability and flexible, scalable manufacturing techniques will enable the commercial sector to rapidly and cost-effectively satisfy military requirements and enhance the US industrial base.

(U) The Uncooled Integrated Sensors project addresses a long standing Defense requirement for uncooled, solid state advanced infrared sensor arrays for major weapons systems that do not require costly cryogenic cooling packages.

(U) The Electronic Module Technology project is a broad initiative to substantially decrease the cost and increase the performance of weapon systems through the timely insertion of state-of-the-art electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components. It includes traditional approaches such as printed circuit boards and emerging technologies such as high density Multichip Modules (MCMs).

(U) The Tactical Information Systems project will design and develop prototype modules, using core technologies that sense, think and communicate, and integrate them into selected personal information products. The project is also demonstrating the feasibility of combining real-time visual images of the environment with geospatially registered computer generated information for use by individual mounted and dismounted warfighters.

(U) Advanced Lithography technology has enabled the dramatic growth of integrated circuit capability. Advances have led directly to improvements in electronic and computing systems performance in terms of speed, power, weight and reliability.

(U) The Microelectromechanical Systems (MEMS) project is a broad and cross-disciplinary initiative to develop an enabling technology that merges computation with sensing and actuation to realize new systems for both perceiving and controlling weapons systems, processes and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS conveys the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical systems. The microfluidic molecular systems program will address issues centered around the development of automated

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E

microsystems that integrate biochemical fluid handling capability along with electronics, opto-electronics and chip-based reaction and detection modules to perform tailored analysis sequences for monitoring of environmental conditions, health hazards and physiological states.

(U) The goal of the Mixed Technology Integration project is to revolutionize the integration of mixed technologies at the micrometer/nanometer scale. This will produce low-cost, lightweight, low-power 3-D microsystems that improve battlefield awareness and the operational performance of military platforms. This project will leverage industrial manufacturing infrastructure to produce mixed-technology microsystems that will revolutionize the way warfighters see, hear, taste, smell, touch and control environments.

(U) Finally, two on-going DARPA projects complete in FY 2000: Centers of Excellence (MT-07) and Manufacturing Technology Applications (MT-08). The Centers of Excellence project finances demonstration, training and deployment of advanced manufacturing technologies. The Manufacturing Technology Applications project reduces the cost and acquisition lead-time of future military systems by integrating manufacturing process considerations during the product design phase and by demonstrating high efficiency multi-product prototype factories. This project enables manufacturers to economically produce military variants of their commercial products in limited quantities through the introduction of flexible process technologies.

(U) **Program Change Summary:** (*In Millions*)	**FY 1999**	**FY 2000**	**FY 2001**
Previous President's Budget	265.442	246.023	233.198
Current Budget	259.577	246.023	193.000

(U) **Change Summary Explanation:**

FY 1999 Decrease reflects a $1.4 million reprogramming out of the PE as part of the Omnibus reprogramming and below threshold reprogramming for the SBIR program.

FY 2001 Decrease reflects the repricing of various elements within the Mixed Technology Integration project and the transition of the MEMS insertion efforts from the component-oriented Devices and Processes/Reliability program to specific programmatic applications.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-03			

COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Uncooled Integrated Sensors MT-03	12.473	10.791	12.000	7.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The Uncooled Integrated Sensors project addresses the technology necessary to produce affordable, infrared (IR) sensor arrays, essential to major weapon systems. The focal plane array consists of a two-dimensional detector array sensitive in a broad spectral range, integrated with unique signal processing to enhance performance and provide more efficient utilization of the information. The critical elements of the technology addressed in this program include the infrared material, detector array fabrication, read-out electronics, cryogenic packaging and testing, and module assembly. Processing and fabrication techniques focus on the production of affordable arrays, at low volume, in the configurations required by weapon systems. Performance enhancements in uncooled infrared and near-infrared sensors are also being addressed to provide an integrated, broadband two dimensional sensor array without the cryogenic package usually associated with infrared sensors. Thermal Imaging Devices will develop new imaging at the theoretical limit, (five to fifty times increase over current uncooled devices), achieving high performance in extremely small, low power configurations and demonstrating technology to open new applications for imaging devices.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Uncooled Imaging Sensors. ($ 10.150 Million)
  - Demonstrated uncooled infrared array with thermal sensitivity of 0.05° C. Demonstrated low power micro-bolometer sensor for unattended ground sensors. Fabricated and tested uncooled infrared array and low power solid state low light level array.
- Thermal Imaging Devices. ($ 2.323 Million)
  - Fabricated and evaluated microstructures with thermal isolation properties five to ten times less than current thermal devices.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-03

(U) **FY 2000 Plans:**

- Uncooled Imaging Sensors. ($ 2.791 Million)
  - Demonstrate 480x640 uncooled with < .05 milli-kelvin, 1 mil pixel. Transfer 480x640 uncooled infrared sensor to Army missile seeker program. Field evaluation of high sensitivity uncooled infrared sensor with low light sensor for ground operations.
- Thermal Imaging Devices. ($ 8.000 Million)
  - Demonstrate non-contact read-out devices and characterize sensitivity/noise sources. Demonstrate non-contact imaging array with thermal sensitivity of 100 milli-kelvin.

(U) **FY 2001 Plans:**

- Thermal Imaging Devices. ($ 12.000 Million)
  - Demonstrate 25 gram imaging sensor with performance acceptable for micro-air-vehicles. Optimize read-out structure to read signals with short (approx. 1 msec.) integration time.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Sept 99	Demonstrate low power micro-bolometer sensor for unattended ground sensors.
Sept 99	Fabricate and test uncooled infrared array and low power solid state low light level array.
Sept 00	Field evaluation of high sensitivity uncooled sensor with low light level sensor for ground operations.
Mar 00	Demonstrate non-contact read-out devices and characterize sensitivity/noise sources.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-04				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Electronic Module Technology MT-04	60.755	56.686	35.650	35.149	39.667	38.029	34.829	Continuing	Continuing

(U) **Mission Description:**

(U) The Electronic Module Technology Project is a broad initiative to substantially decrease the cost and increase the performance of weapon systems through the timely insertion of state-of-the-art electronic modules. Electronic module technology addresses the design and fabrication of various types of digital, analog and mixed signal modules consisting of electronic, electro-optical and micro-mechanical components. It includes traditional approaches such as printed circuit boards and emerging technologies such as high density Multichip Modules (MCMs).

(U) The project has four major objectives: (l) shorten the overall design, manufacture, test and insertion cycle for advanced electronic subsystems; (2) advance the state-of-the-art in electronic interconnection and physical packaging technology to allow circuits to operate close to their intrinsic maximum speed with less overhead in terms of volume, weight and cost; (3) provide a robust manufacturing infrastructure for electronic modules; and (4) demonstrate the system level payoff of electronic module technology through advanced technology demonstrations (ATDs).

(U) The project has the following major elements: Photonic Analog/Digital (A/D) Conversion; Distributed Robotics; Design Support for Mixed Technology Integration (Composite CAD) and the Molecular-level Large-area Printing (MLP) program. Photonic Analog/Digital (A/D) conversion will utilize breakthrough photonic developments to substantially increase the speed by which analog signals are converted into digital data streams for data reduction and processing. Distributed Robotics is an effort to integrate developments in MEMS, power sources, communications and advanced microelectronics to design, construct and field multiple, high-performance, mobile, autonomous systems. Composite CAD seeks to develop the design tools (concept exploration, analysis, optimization and verification) to allow thousands of analog, digital, optical, MEMS and microfluidic devices to be integrated into "systems-on-a-chip" and other highly integrated mixed technology systems. The MLP program is exploring approaches to 'print' MEMS devices on large surfaces.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-04

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- OMNET. ($ 11.000 Million)
  - Demonstrated integrated optoelectronic transceivers and optical switches for reconfigurable interconnections of sensors to processors and the ability to distribute computation across military platforms 1-100 meters in length for future Electronic Warfare/digital radar and image processors.
- Distributed Robotics. ($ 13.000 Million)
  - Constructed the unit platforms, integrated commercial or demonstrated technology elements (e.g., imagers, MEMS, wireless systems), and defined multiple, cooperative functions for selected military applications.
- Composite CAD. ($ 15.763 Million)
  - Continued to develop the mixed domain software (kinematic, electric, electrostatic, and fluidic) analysis of micro-machined devices, systems of devices and corresponding electronic circuits to support the design of composite electronic sensors and systems.
- Photonic A/D. ($ 9.000 Million)
  - Initiated photonic A/D converter development to achieve breakthrough in high speed A/D conversion.
- Molecular-level Large-area Printing (MLP). ($ 11.992 Million)
  - Completed experimental characterization of first generation printing processes. Selected second generation printing process.

(U) **FY 2000 Plans:**

- Photonic A/D. ($ 15.100 Million)
  - Evaluate alternative photonic clock, optical sampler and quantizer module designs for photonic A/D converters operating in the 10-100 Giga-sample-per-second range and identify high impact applications for this technology.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-04

- Distributed Robotics. ($ 18.000 Million)
  - Demonstrate feasibility of a variety of multiple robots (<5cm) to operate in specific military environments and their ability to adapt to varying environments and missions.

- Composite CAD. ($ 9.544 Million)
  - Complete the development of systems software design and simulation capabilities for mixed technology micro-systems, including MEMS-enabled designs and microfluidic (Micro-Flumes) designs. The ultimate goal of the complete systems design capability is to enable mixed technology systems-on-a-chip. Provide mixed technology design libraries, models and test structure data to improve design quality, development time and ability to reuse designs.

- Molecular-level Large-area Printing (MLP). ($ 14.042 Million)
  - Concentrate on the development and choice of non-conventional large-area, MLP techniques for a demonstration system. Establish overlay capabilities for MLP.

(U) **FY 2001 Plans:**

- Photonic A/D. ($ 13.500 Million)
  - Complete initial photonic A/D converter evaluation and finalize design for demonstration module.

- Distributed Robotics. ($ 12.000 Million)
  - Demonstrate multiple robots with overall functionality and probability of mission success improved by integration of optimized control strategies.

- Molecular-level, Large-area Printing (MLP). ($ 10.150 Million)
  - Demonstrate and characterize 10,000 x 100 pixel density array on a spherical surface.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-04

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Nov 99	Initial prototype of tightly integrated adaptive payload technology.
Apr 00	Characterization of single crystal semiconductors on amorphous surfaces.
Jun 00	Establish overlay capabilities for MLP.
Sep 00	Design and initiate fabrication of demonstration sensor array.
Sep 00	Demonstrate initial PCM designs (<10-femtosecond jitter, 100 on W output).
Jul 01	Demonstrate and characterize 10,000 x 100-pixel density array on spherical surface.
Aug 01	Demonstrate multiple robots with overall functionality and probability of mission success improved by integration of optimized control strategies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-05

COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Tactical Information Systems MT-05	32.112	20.205	15.600	23.100	16.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This project will develop the technology for transmitting and displaying critical situational awareness and surveillance information to the warfighter. This project consists of Smart Modules, Warfighter Visualization and Ultra-Wideband Communications. Smart Modules will design, develop and integrate prototype modules using core technologies that communicate into personal information products. Warfighter Visualization efforts demonstrate the feasibility of combining real-time visual images of the environment with geospatially registered computer-generated information. Ultra-Wideband Communications will exploit the bandwidth to communicate in an urban terrain, a background with very high clutter, or to counter jamming. Together these systems will provide the mounted and dismounted warfighter with an unprecedented awareness in the most hostile environments.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Smart Modules. ($ 16.562 Million)
  - Demonstrated a novel capture device that incorporates signal and data processing in a 3-D package for use by individual soldiers. This miniature device, weighing only a few ounces, is able to capture an image and rapidly analyze movement or correlate images with all processing done on the focal plane. The camera is compact enough to be worn by individual soldiers and communicate via a radio to and from geographic information system databases.
  - Demonstrated a wearable computer incorporating wireless communication in a one pound, one-watt configuration. This represents a three-fold improvement in weight and a ten-fold improvement in power over current technology. The wearable computer will be used in a wide variety of space applications by the small unit operations soldier.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-05

- Warfighter Visualization. ($ 15.550 Million)
  - Demonstrated ability to do precision, real-time georegistration using video from the Predator unmanned aerial vehicle. This capability enables vastly enhanced situational awareness by obviating the "soda straw" effect of narrow field of view video. This technology development was rapidly accelerated and used to provide coordinates on mobile targets at the Combined Allied Operation Center in support of Operation Allied Force.
  - Demonstrated prototype capability for dismounted soldiers to view the real world with tactical symbology in a battlefield environment. This technology makes use of a novel optical tracking technology that uses novel compact image processing hardware to back compute the location of camera from points in the scene. This capability provides location information in urban environment where GPS is jammed or blocked.

(U) **FY 2000 Plans:**

- Warfighter Visualization. ($ 20.205 Million)
  - Demonstrate a high performance special purpose processor that will take the capabilities of real-time georegistration and precision targeting demonstrated in Vicenza, Italy and shrink them onto a single chip. This will shrink the system for vehicle mounting or ultimate portability by a dismounted soldier or in handheld units such as night vision goggles.
  - Demonstrate a prototype advanced human interface capability for use in conjunction with other bodyworn processing units. This system will combine "supernormal" listening with tactile inputs and displays for a dismounted soldier.
  - Demonstrate full-surround foveal vision system for glass turret. This system matches the human visual system by providing high resolution only where it is needed in the visual field, but provides a seamless image using advanced video processing system.

(U) **FY 2001 Plans:**

- Warfighter Visualization. ($ 10.600 Million)
  - Demonstrate 3D-georegistration system for ground soldiers. This capability will develop high speed rendering technology necessary to match ground soldier's actual view to model view for precise positioning of tactical overlay on the soldier's visual field.
  - Demonstrate motion analysis derived from a tactical mosaic database. This capability will use motion extraction and other complex strategies to view complex time-correlated events on the ground.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-05

- Demonstration of extremely high precision "tunnel mosaics" from unattended aerial vehicle expendables. This technology will effectively enable targets to be viewed with 100X current precision limits from a low cost expendable. This enables high-assurance targeting and greater survivability for air platforms due to shorter loiter times.

- Ultra-Wideband Communications. ($ 5.000 Million)
  - Assess attenuation of the signal in hostile terrain and in the presence of jamming.
  - Develop accurate geolocation schemes utilizing the ultra-wideband waveform.
  - Develop and assess innovative waveforms to decrease the chance of enemy signal intercept and exploitation.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Smart Modules:	
Dec 99	Build and test Advanced Humanistic Platform prototype.
Warfighter Visualization:	
Dec 99	Develop hybrid sensor tracking features and including "smart camera" functions to allow collaborative updates between soldiers.
Jul 00	Develop real-time visual data correlation system in dismounted and mounted warrior applications.
Jul 01	Demonstrate dynamic multi-sensor I/O in both dismounted and mounted military applications.
Ultra-Wideband Communications:	
Jun 01	Test attenuation of signal in realistic environments.
Sep 01	Assess probability of detection by enemy intercept.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-06				

COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Microwave and Analog Front End Technology MT-06	3.809	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The DoD is now far ahead of the commercial world in microwave and millimeter wave technology in terms of performance characteristics. However, in many cases, radio frequency (RF) sub-system costs are still a major impediment to fielding DoD weapon systems. Material, processes and design technology advances must be undertaken to sustain an effective defense capability and to maintain U.S. dominance in this critical technology area. The MAFET program has addressed this problem by: (1) reducing design time and cost for every RF system being developed or upgraded through an improved microwave/millimeter wave design environment; (2) breaking the very expensive cycle and time-consuming current practice of design-build-test--redesign-rebuild-retest; (3) establishing repeatable, robust processes to produce high frequency components; (4) making strategic investments in critical passive, packaging and integrated circuits devices needed for millimeter wave systems; and (5) investigating revolutionary solutions to the long-standing problem of insufficient power in solid-state radar and communications transmitters.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Quasioptics Area. ($ 1.809 Million)
  - Demonstrated a set of quasioptical grid-, array-, card- and slab-combined power amplifiers.

- MEMS-switch Area. ($ 1.000 Million)
  - Demonstrated MEMS-tunable Chebyshev filter operating at 20 and 45 GHz; demonstrate MEMS-array transmitting beam-steerer at 44 GHz.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-06

- Micromachined Circuits and Novel Thermal Management Area. ($ 1.000 Million)
  - Demonstrated a micromachined SSPA ("W-Band Power Cube") having 2 W/in^2 intensity radiated from top facet. The power cube was fabricated with InP Power MMICs that are thermally managed by bump bonding and are coupled to free space by Si-micromachined feed-line and planar-antenna structures.

(U) **FY 2000 Plans:**

- Not Applicable.

(U) **FY 2001 Plans:**

- Not Applicable.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Sep 99	Demonstrate full interoperability of CAD vendors.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-07				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Centers of Excellence MT-07	6.062	4.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This project provides funding for the Robert C. Byrd Institute for Advanced Flexible Manufacturing at Marshall University. The Byrd Institute provides both a teaching factory and initiatives to local area industries to utilize computer-integrated manufacturing technologies and managerial techniques to improve manufacturing productivity and competitiveness. Training includes technologies to significantly reduce unit production and life cycle costs and to improve product quality. This project also includes funding for the U.S.-Japan Management Training Program whose purpose is to build a growing infrastructure of American scientists and engineers with knowledge about the Japanese R&D enterprise and provide training in the Japanese language, and has funded the Defense Techlink Rural Technology Transfer Project.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Advanced Flexible Manufacturing. ($ 3.618 Million)
  - Completed expansion of the Institute for Advanced Flexible Manufacturing's satellite facilities.
- U.S.-Japan Management Training. ($ 1.444 Million)
  - Completed efforts with centers of excellence to support students', researchers' and executives' understanding of Japan's manufacturing infrastructure, culture and language.
- Defense Techlink Rural Technology Transfer Project. ($ 1.000 Million)
  - Provided funding for the Defense Techlink Rural Technology Transfer Project.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-07

(U) **FY 2000 Plans:**

- Advanced Flexible Manufacturing. ($ 4.000 Million)
  - Complete assessment of the Institute for Advanced Flexible Manufacturing's performance and transition from DoD to state/private support.

(U) **FY 2001 Plans:**

- Not Applicable.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Oct 00	Complete assessment and transition of the Institute from DoD to state/private support.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-08				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Manufacturing Technology Applications MT-08	20.385	21.846	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) Future military systems will be affordable only if the manufacturing process is considered as an integral part of product design, production takes place in flexible, multi-product factories and if advanced manufacturing technology is combined effectively with advanced business practices. This program focuses on demonstrations of process technology combined with innovative industrial practices and will measure the improvements in cost, schedule and quality achievable in key defense product areas.

(U) The Affordable Multi-Missile Manufacturing (AM3) program is an Advanced Technology Demonstration initiated in FY 1995. The objective of AM3 is to demonstrate the feasibility of 25-50 percent reductions in the unit cost of tactical missiles, in ongoing missile production programs, in new missiles and major modifications. This will be accomplished by teams of missile prime contractors, component suppliers and manufacturing equipment and software vendors who develop and demonstrate the combined effects of advanced design, manufacturing, assembly systems and processes, missile value engineering changes, and acquisition reform and business practice innovations. A major technical theme is to achieve economies across a mix of missiles to compensate for the decline in individual missile quantities. Demonstrations will be conducted in the design and manufacture of components and guidance and control/seeker assemblies for multiple missiles, including R&D and production programs.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- Affordable Multi-Missile Manufacturing. ($ 20.385 Million)
  - Established Technology Product Centers (TPCs) in key design product areas that use modular reusable design and standards parts concepts.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY **Error! Reference source not found.** BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-08

- Established multi-product factory and multi-missile factory utilizing multi-missile factory concepts.
- Continued progress with key suppliers on sourcing strategies, working toward completion of a supplier affordability process.
- Completed design phases of reusable hardware demonstration projects – involving inertial measurement unit (IMU), common processor, and common infrared (IR) test station – and began validation and insertion.
- Continued rapid product development and producibility demonstrations on brilliant anit-tank (BAT), joint standoff weapon (JSOW), standard missle-2 (SM-2), extended range guided munitions (ERGM), and experimental munition-982 (XM-982) toward eventual completion and deployment in FY 2000.
- Successfully completed Activity Based Management demonstration at Ocala facility.
- Completed training for missile suppliers AM3 programs and awarded contracts for affordability initiative demonstrations.
- Completed planning and simulation for multi-missile factory demonstration, gaining approval to proceed with implementation.
- Continued progress with common family of parts demonstrations, awarding contracts for common IMU and progressing in other MEMS and IFOG/RLG efforts.
- Completed installation of Integrated Enterprise Resource Planning software, now operational.
- Continued progress in rapid product design environment – new design tools now operational.
- Completed validation and definition for use of commercial electronic parts in missile applications.

(U) **FY 2000 Plans:**

- Affordable Multi-Missile Manufacturing. ($ 21.846 Million)
  - Complete integration of flexible factory assembly areas, to include to common and product specific manufacturing stations.
  - Complete design and prototype fabrication of low cost inertial measurement unit (IMU).
  - Complete design verification test and integration for common processor.
  - Complete integration of gyro optics assembly fabrication and mid-body casting demonstration.
  - Complete common seeker commercial parts test evaluation, producibility analysis and flight-test.
  - Complete process design for flexible multi-product assembly cells, validate on production parts and demonstrate on production line.
  - Complete electronic procurement, electronic collaboration tools and supplier integration demonstrations.
  - Complete demonstration of standard parts and processes and design reuse.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-08

(U) **FY 2001 Plans:**

- Not Applicable.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Affordable Multi-Missile Manufacturing	
Oct 99	Complete integration of flexible factory assembly areas.
Oct 99	Complete common seeker commercial parts test evaluation, producibility analysis, and flight test.
Dec 99	Complete AM3 Phase 3 multi-missile manufacturing demonstrations.
Jan 00	Complete common inertial measurement unit design verification test, prototype demonstration unit and technology insertion review.
Mar 00	Complete common processor design verification test and integration.
Mar 00	Complete process design for flexible multi-product assembly cells, validate on production parts and demonstrate on production line.
Jun 00	Complete flight tests of AM3 missile seeker prototypes.
Jul 00	Complete integration of guided flight unit, gyro optics assembly fabrication and mid-body casting demonstrations.
Jul 00	Complete electronic procurement and supplier integration demonstrations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-10				

COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Lithography MT-10	48.026	39.000	44.900	45.000	45.000	45.000	45.000	Continuing	Continuing

(U) **Mission Description:**

(U) Microelectronics is a key to improved weapon system performance and lithography technology has enabled the dramatic growth in microelectronics capability over the past three decades. The improved capabilities in semiconductor technology contribute to significant system gains in speed, reliability, cost, power consumption and weight. Advanced microelectronics technology is essential for computing and signal processing in virtually all military systems including command, control, communications and intelligence; electronic warfare; and beam forming for radar and sonar. Further improvements in areas such as target recognition, autonomous guided missiles and digital battlefield applications require microcircuits with smaller features to meet the operational speed, power, weight and volume constraints of these systems.

(U) Current microelectronics fabrication utilizes feature sizes of 0.35 microns. The Advanced Lithography Program emphasizes longer-term research with expected high payoff in the fabrication of semiconductor devices with 0.1 or less micron feature sizes. These programs will develop technology for sub 0.1-micron features.

(U) The goal of the lithography program is to reduce technical barriers in the development of advanced lithographic technologies for the fabrication of a broad range of microelectronic devices and structures. Innovative research in pattern generation and transfer, imaging materials, new process and metrology will provide alternatives beyond current evolutionary trends. The program will investigate technologies for the creation of highly-complex patterns at sub 0.10μm resolution over field areas in excess of 1000 mm^2. Applications with larger geometries will be explored for innovative devices and structures beyond microelectronics.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-10

(U) **<u>Program Accomplishments and Plans:</u>**

(U) **<u>FY 1999 Accomplishments:</u>**

- Sub 0.1 Micron Technology. ($ 24.887 Million)
  - Continued efforts in maskless lithography, including arrays of miniature e-beam columns, novel imaging materials and pattern transfer processes. Continued network of university efforts in novel patterning. Completed column test stand for maskless e-beam writer.

- Laser Plasma X-ray Source. ($ 5.951 Million)
  - Continued laser plasma x-ray source technology.

- X-ray Masks. ($ 13.888 Million)
  - Continued x-ray mask writer development. Developed x-ray masks for the F-22, Apache Longbow and other defense programs.

- Nanotechnology and Crystalline Arrays. ($ 3.300 Million)
  - Initiated research in nanotechnology and crystalline control arrays.

(U) **<u>FY 2000 Plans:</u>**

- Sub 0.1 Micron Lithographies. ($ 23.000 Million)
  - Develop key tool components, materials and processing to accelerate the availability of emerging lithography technologies beyond 193 nm. Efforts will include maskless (electron beam, ion beam) approaches and the projection technologies, using optical, electron, x-rays and extreme ultraviolet.

- Support Technologies. ($ 16.000 Million)
  - Develop support technologies, to include mask technology, resists and metrology. Develop innovative optics designs and architectures and new materials and processing beyond the evolutionary trends in the industry.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-10

(U) **FY 2001 Plans:**

- Sub 0.1 Micron Lithographies. ($ 25.900 Million)
  - Demonstrate key components of maskless wafer writer and characterize performance.

- Support Technologies. ($ 19.000 Million)
  - Accelerate technology developments in the lithography exposure sources and supporting (cross-cutting) technologies needed for microelectronics fabrication. Develop reduced risks in key areas of components, materials and processing allowing industry to fabricate prototype tools and new high-performance devices for use in advanced military systems and commercial markets.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Jul 00	Demonstrate ion microcolumn for maskless lithography.
Mar 01	System demonstration of maskless wafer writer.
Aug 02	Demonstrate key components for lithography of 0.07-micron features.
Sep 02	Demonstrate key components for mask writer for sub 0.1-micron features.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Microelectromechanical Systems (MEMS) MT-12	75.955	71.498	42.350	38.575	37.100	31.325	18.125	Continuing	Continuing

(U) **Mission Description:**

(U) The Microelectromechanical Systems (MEMS) program is a broad, cross-disciplinary initiative to develop an enabling technology that merges computation and power generation with sensing and actuation to realize a new technology for both perceiving and controlling weapons systems and battlefield environments. Using fabrication processes and materials similar to those that are used to make microelectronic devices, MEMS provides the advantages of miniaturization, multiple components and integrated microelectronics to the design and construction of integrated electromechanical and electro-chemical-mechanical systems. The MEMS program addresses issues ranging from the scaling of devices and physical forces to new organization and control strategies for distributed, high-density arrays of sensor and actuator elements. These issues include microscale power and actuation systems as well as microscale components that survive harsh environments. The microfluidic molecular systems program will address issues centered around the development of automated microsystems that integrate biochemical fluid handling capability along with electronics, optoelectronics and chip-based reaction and detection modules to perform tailored analysis sequences for the monitoring of environmental conditions, health hazards and physiological states.

(U) The MEMS program has three principal objectives: the realization of advanced devices and systems concepts; the development and insertion of MEMS into DoD systems; and the creation of support and access technologies to catalyze a MEMS technology infrastructure. These three objectives cut across a number of focus application areas to create revolutionary military capabilities, make high-end functionality affordable to low-end systems and extend the operational performance and lifetimes of existing weapons platforms. The major technical focus areas for the MEMS program are: 1) inertial measurement; 2) fluid sensing and control; 3) electromagnetic and optical beam steering; 4) mass data storage; 5) chemical reactions on chip; 6) electromechanical signal processing; 7) active structural control; 8) analytical instruments; and 9) distributed networks of sensors and actuators.

(U) Among the many accomplishments to date are: a wind-tunnel test of an integrated MEMS sensor and actuator array distributed along the leading edge of a model aircraft wing creating rolling moments of sufficient strength to control aircraft flight, pointing the way to future fighter aircraft with advanced maneuverability unattainable using conventional, large and discrete control surfaces; a demonstration of a MEMS-based accelerometer capable of surviving and operating in the near 100,000 G accelerations generated by firing artillery shells, making possible affordable

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

guidance systems to what are presently unguided munitions and increasing both their effectiveness and life cycle costs; and the establishment of a regularly scheduled, shared, MEMS fabrication service for domestic DoD, commercial and academic users. The MEMS program has initiated new efforts in: low power miniaturized communications systems; distributed control aircraft roll and yaw; microscale power; micro airborne sensor/communication systems; data storage; and inertial systems.

(U) Within this project is the development of totally integrated microfluidic chips to enable ubiquitous yet unobtrusive assessment of the warfighter's body fluids. These microchips integrate detection, diagnostics, and treatment in one chip-scale system called Bio-Fluidic chips.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- MEMS Devices and Processes. ($ 17.344 Million)
  - Demonstrated radio frequency electromechanical signal processing; MEMS-based mass data storage; massively parallel read/write structures; micro thrusters for satellite attitude, propulsion and control.

- MEMS System Design and Development. ($ 20.379 Million)
  - Initiated concept demonstrations for systems in the form of aerodynamic control of model aircraft; low-power wireless integrated microsensor for structural health, maintenance and monitoring; gas-phase microinstruments; polymer-based MEMS; and micro power sources. Demonstrated a MEMS miniaturized fuze/safety and arming device for use in small diameter submarine torpedo counter weapons.

- MEMS Support and Access Technology. ($ 19.132 Million)
  - Integrated development in robotics and ultra-miniaturized electronics to design, construct and field mutiple, high performance, mobile, autonomous systems.

- CAMD. ($ 3.863 Million)
  - Continued micro device manufacturing processes at the Center for Advanced Microstructures and Devices (CAMD).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

- Microfluidics. ($ 15.237 Million)
  - Demonstrated a microfluidic sensor system capable of indicating specific DNA hybridization events. Demonstrated detection of pathogens or protein molecules without requiring reporters by using coated beads and DEP/FFF/IS (dioelectrophoresis-field flow fractionation-impedance sensor). Demonstrated prototype microfluidic system to reconstitute a 20-ml volume of lyophilized material in one minute to five-percent reconstitution accuracy using thermocapillary pumping and mixing.
  - Demonstrated automated isothermal DNA analyzer: multichannel, microchip device with integrated aerosol collector. Demonstrated portable biodetector prototype with sensitivity for three types each of bacteria, viruses and toxins as well as sensitivity to unknown toxicants by cell or coated beads.

(U) **FY 2000 Plans:**

- MEMS Devices and Processes. ($ 30.489 Million)
  - Develop new devices and processes that survive extremely harsh environments and subsequently the integration of micro-mechanical as well as micro-chemical systems into electronic circuits. These new devices include micro power sources, mechanical-microprocessor units, micro actuators, communication components, MEMS aerodynamic pressure sensors on flexible adhesive tape substrate; modular, monolithically integrated MEMS Inertial Measuring Unit (IMU); and MEMS high-temperature sensor and actuator arrays.
  - Complete on-going insertion contracts initiated in prior years. Demonstrate micro devices that will reduce communication equipment to the size of a credit card; optimize the aerodynamics of an airplane wing for lift and drag; provide intelligence to machine components to allow them to report their condition and state of readiness (e.g., "smart wheel bearings"); and increase the resistance of jamming of GPS used on smart munitions. Integrate power sources with the MEMS devices and expand the use of MEMS in fluidic applications.

- MEMS System Design and Development Phase II. ($ 18.079 Million)
  - Initiate technology demonstrations relevant to micro airborne sensor/communicator platforms and chemically powered remote sensors; subsystems for PicoSatellites; electromechanical signal processing; and nanoelectromechanical systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

- MEMS Support and Access Technologies. ($ 13.930 Million)
  - Incorporate MEMS microassembly, packaging and fabrication processes at distributed sites for robust sourcing of Integrated MEMS systems.
- Bio-Fluidic Chips (BioFlips). ($ 9.000 Million)
  - Design microscale fluidics integrated with optical and/or electronic detection to monitor cellular activities of body fluids; design chip interface with bio-fluids for continuous sampling and fluids delivery; develop on-chip reagent storage and reconstitution.

(U) **FY 2001 Plans:**

- MEMS Devices and Processes/Reliability. ($ 11.625 Million)
  - Continue development of devices and processes for the integration of micro-mechanical and micro-chemical devices into electronics, resulting in new devices such as micro power sources, mechanical microprocessor units, micro actuators and communication components.
- MEMS System Design and Development. ($ 7.930 Million)
  - Perform concept demonstrations for systems in the form of "smart dust," micro airborne sensor/communicator platforms, chemically powered remote sensors and atomic level data storage.
- MEMS Support and Access Technologies. ($ 4.795 Million)
  - Complete integration of MEMS microassembly, packaging and fabrication at distributed sites for robust sourcing of Integrated MEMS systems.
- Bio-Fluidic Chips (BioFlips). ($ 18.000 Million)
  - Develop closed-loop bio-fluidic chips to regulate cellular transduction pathways and precise dosage of chemicals/drugs/ reagents/enzymes; fabricate and test individual microfluidic chip components and integrated sensors for flow control; manipulate (pump/valve/sense) bio-fluids in integrable microfluid components.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-12

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Feb 00	Demonstrate electromechanical signal processing.
May 00	Demonstrate MEMS aerodynamic pressure sensors on flexible, polyamide belt.
May 00	Demonstrate modular, monolithically integrated MEMS IMU.
Aug 00	Demonstrate subsonic roll, pitch and yaw control via MEMS.
Sep 01	Demonstrate atomic resolution data storage.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Mixed Technology Integration MT-15	0.000	21.997	42.500	46.010	50.000	50.000	50.000	Continuing	Continuing

(U) **Mission Description:**

(U) The goal of the Mixed-Technology Integration project is to leverage advanced microelectronics manufacturing infrastructure and DARPA component technologies developed in other projects to produce mixed-technology microsystems that will revolutionize the way individuals see, hear, taste, smell, touch and control their environment at-a-distance, a paradigm that addresses many of the present and future needs of the DoD. These 'wrist watch-size', low-cost, lightweight and low power microsystems will improve the battlefield awareness and security of the warfighter and the operational performance of military platforms. At the present time, systems are fabricated by assembling a number of mixed-technology components: microelectronics, microelectromechanical systems (MEMS), microphotonics, microfluidics and millimeterwave/microwave. Each technology usually requires a different level of integration, occupies a separate silicon chip and requires off-chip wiring, fastening and packaging to form a module. The chip assembly and packaging processes produce a high cost, high power, large volume and lower performance system. This program is focused on the monolithic integration mixed technologies to form batch-fabricated, mixed technology microsystems 'on-a-single-chip' or an integrated and interconnected 'stack-of-chips'.

(U) Microelectronics incorporates micrometer/nanometer scale integration and is the most highly integrated, low-cost and high-impact technology to date. Microelectronics technology has produced the microcomputer-chip that enabled or supported the revolutions in computers, networking and communication. This program extends the microelectronics paradigm to include the integration of heterogeneous or mixed technologies and thereby create a new class of 'match-book-size', highly integrated device and microsystem architectures. Examples of component-microsystems include low-power, small-volume, lightweight, microsensors, microrobots and microcommunication systems that will improve and expand the performance of the warfighter, military platforms, munitions and UAVs.

(U) The program includes the integration of mixed materials on generic substrates including glass, polymers and silicon. The program is design and process intensive, using 'standard' processes and developing new semiconductor-like processes and technologies that support the integration of mixed-technologies at the micrometer/nanometer scale. The program includes the development of micrometer/nanometer scale isolation, contacts, interconnects and 'multiple-chip-scale' packaging for electronic, mechanical, fluidic, photonic and rf/mmwave/microwave technologies. For example, a mixed-technology microsystem using integrated microfluidics, MEMS, microphotonics, microelectronics and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

microwave components could provide a highly integrated, portable analytical instrument to monitor the battlefield environment, the physical condition of a warfighter, the identity of warfighters (friend or foe) or the combat readiness of equipment. The ability to integrate mixed technologies onto a single substrate will drive down the size, weight, volume and cost of weapon systems while increasing their performance and reliability.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Not Applicable.

(U) **FY 2000 Plans:**

- Three-D Imaging Devices. ($ 7.357 Million)
  - Initiate program to develop new high speed imaging device technology to rapidly acquire a high resolution 3-D image of a tactical target at ranges of 7-10 kilometers increasing identification range of tactical targets, especially from fast moving platforms. Develop near infrared materials with point defect density less than 1000/sq cm. Demonstrate 4x4 array of detectors with gain of 30 at 1GHz. Complete investigation of novel high gain detector concept.

- Steered Agile Laser Beams. ($ 6.867 Million)
  - Initiate program to develop compact, light weight, man-portable, electronically steered lasers to replace large, heavy gimbal mounted lasers in lasercom links and smart weapon target designators. Develop small, lightweight laser beam scanner system technologies for replacement of gimbaled mirror systems. Initiate system design and component specifications; select system design.

- RF Lightwave Integrated Circuits (R-FLICS). ($ 7.773 Million)
  - Initiate program to demonstrate, with heterogeneous integration, lightwave and RF technologies to route, control and process analog RF Signals in the 0.5-50 GHz range. Develop RF-Photonic modules that enable links with better than zero net RF loss from input to output. Develop and demonstrate optically integrated modules capable of performing complex RF functions such as signal channelization or single chip generation of multiple RF signals.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

(U) **FY 2001 Plans:**

- Three-D Imaging Devices. ($ 14.500 Million)
  - Complete design of high speed electronics for sub-nanosecond detection. Integrate high speed electronics with 5x5 detector array and integrate into brass board imaging system. Demonstrate laboratory imaging with 5x5 array. Select detector design for 128x128 3-D imaging array.
- Steered Agile Laser Beams. ($ 15.500 Million)
  - Develop electronically steered laser beam technology for use in covert, anti-jam, high bandwidth battlefield communications - hand held ground-to-ground recon units, which are able to transmit images and geo-location data of targets, and for use in target designators for small unit operations in high threat environments. Fabricate beam steering emitters and detectors.
- RF Lightwave Integrated Circuits (R-FLICS). ($ 12.500 Million)
  - Focus program on identified key applications for integrated RF-Photonic modules and produce initial prototypes and demonstrate methods for evaluation of their performance. Initiate parallel efforts to develop components for efficient RF links exhibiting better than zero net loss and to demonstrate the advantages of integrated optical-RF modules for RF systems. Down select among technology options and develop prototype module for demonstration.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Advanced Electronics Technology PE 0603739E, Project MT-15

(U) **Schedule Profile:**

Plan	Milestones
3-D Imaging:	
May 00	Develop low defect density near infrared materials suitable for high speed imaging.
Aug 00	Demonstrate detector test arrays with gain/bandwidth product capable of sub-nanosecond detection at long range.
Feb 01	Integrate novel, high gain/bandwidth detector array with low noise electronics.
Steered Agile Laser Beams:	
Feb 00	Select system configuration that best meets insertion target performance goals.
May 00	Derive component specifications.
Aug 01	Fabricate beam steering emitters and detectors.
R-FLICS:	
Feb 01	Demonstrate High Performance R-FLIC Components to 50 GHz bandwidth.
Aug 01	Demonstrate integrated R-FLIC functions such as channelizer with 10 GHz selectivity over 0-50 GHz bandwidth.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)						DATE September 1999		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Electric Vehicles PE 0603747E				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	9.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Electric Vehicles EV-01	9.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The DARPA Electric and Hybrid Vehicle Technology program is pursuing research, development, and demonstrations of technologies for electric and hybrid vehicles that address military missions, modernization, and cost mitigation. Established by Congress in FY 1993, the program has pursued technology development focused on: high-specific power engine/generator sets, including multi-fuel capable, high efficiency, and low emissions turbines, diesels, and rotary engines; power control devices, including high-performance power semiconductors, control algorithms, and circuit integration and packaging; energy storage devices, including advanced batteries, rapid battery recharging, flywheels, and capacitors; electromechanical conversion, including alternating current, direct current, and linear motors; and lightweight high-strength materials, including space-frames and composites. These dual-use electric drivetrain technologies are being demonstrated in both commercial and military chassis. The technologies are directly relevant and are coordinated with the DARPA Combat Hybrid Power Systems (CHPS) and Reconnaissance Surveillance and Targeting Vehicle (RST-V) programs (budgeted under PE 0603764E, Project LNW-01).

(U) The program is transitioning to the Department of Transportation (DOT) in FY 1999. The Research and Special Programs Administration of DOT has budgeted to continue the program in FY 2000.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Electric Hybrid Vehicle Program. ($ 9.000 Million)
  - Completed field testing of the hybrid electric Bradley Fighting Vehicle.
  - Installed flywheels in vehicles.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Electric Vehicles PE 0603747E

- Applied high energy and high power battery systems to vehicles.
- Integrated hybrid electric drivetrain and controls into medium and heavy-duty vehicles.

(U) **FY 2000 Plans:**

- Not Applicable.

(U) **FY 2001 Plans:**

- Not Applicable.

(U) **Program Change Summary:** (*In Millions*)

	FY1999	FY 2000	FY 2001
Previous President's Budget	9.000	0.000	0.000
Current Budget	9.000	0.000	0.000

(U) **Change Summary Explanation:**

- Not Applicable.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Nov 99	Complete field test of hybrid electric Bradley Fighting Vehicle.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	169.370	222.888	140.380	127.483	138.480	149.046	155.671	Continuing	Continuing
Command & Control Information Systems CCC-01	82.299	108.133	70.787	87.734	106.234	114.034	119.834	Continuing	Continuing
Information Integration Systems CCC-02	87.071	114.755	69.593	39.749	32.246	35.012	35.837	Continuing	Continuing

(U) **Mission Description:**

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced information systems research and development concepts.

(U) The Command and Control Information Systems project is developing the technologies necessary to facilitate joint campaign planning and control throughout the battlespace. The primary program in this project is the Joint Forces Air Component Command System (JFACC), which will revolutionize command and control of joint and coalition air forces through the incremental development, integration, evaluation, demonstration, and transition of technology and systems. Other programs addressed in this project include: the Information Assurance Science and Engineering Tools; the Advanced Intelligence, Surveillance and Reconnaissance (ISR) Management (AIM) program; the Agent-Based Systems program; and the Active Templates program.

(U) The Information Integration Systems project will develop the technologies necessary to ensure that the enhanced information required by battlefield combatants is available on a near real time basis. Programs addressed in this project include: the Agile Information Control Environment (AICE) program; the Dynamic Database (DDB) program; the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD); the Airborne Communications Node (ACN) program; the Command Post of the Future program; Ultralog; and the High Frequency/High Bandwidth program.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E

(U) **Program Change Summary:** *(In Millions)*

	FY1999	FY 2000	FY 2001
Previous President's Budget	177.492	222.888	213.380
Current Budget	169.370	222.888	140.380

(U) **Change Summary Explanation:**

FY 1999 Decrease reflects restructuring of the Joint Forces Air Component Command System (JFACC) and Dynamic Database (DDB) programs; termination of the Dynamic-Multi-User Information Fusion (DMIF) program and SBIR reprogramming.

FY 2001 Decrease reflects the restructure in JFACC; reduction in AICE and Dynamic Database programs. In addition, the decrease is due to consolidation of portions of the Information Assurance programs in ST-24; and Project Genoa into Asymmetrical Threats in ST-28, with application-oriented developments remaining in CCC-01.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999		
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Command Control Information Systems CCC-01	82.299	108.133	70.787	87.734	106.234	114.034	119.834	Continuing	Continuing

(U) **Mission Description:**

(U) Military operations that have taken place since the end of the cold war have demonstrated that current theater command, control, communications, intelligence/information systems, and planning and rehearsal systems capabilities lack the ability to support operations in diverse new environments and scenarios. These range from conflict and peacekeeping in urban areas with large civilian populations to heavy battle actions in remote areas. Current capabilities do not provide the Commander with real time, secure, situational awareness, nor the ability to conduct decentralized planning, rehearsal and execution. Additionally, the present systems do not provide flexible interfaces or critical interoperable assured communications. The goals of the programs in this project are to build on an innovative architecture and secure infrastructure to enhance information processing, dissemination and presentation capabilities for the Commander. This will be done by including information pertaining to the disposition of enemy and friendly forces, providing a joint situational awareness picture and improving planning, decision-making and execution support capability and providing secure multimedia information interfaces and assured software to "on the move users". Integration of collection management, planning and battlefield awareness programs is an essential element of our strategy for achieving battlefield dominance through assured information systems.

(U) The Joint Force Air Component Commander (JFACC) Project seeks to catalyze a revolution in military command and control (C2), specifically joint and coalition air operations. The objective of the program is to develop innovative technologies that will enable agile and stable control of distributed military operations conducted in an uncertain and rapidly changing environment, dramatically enhancing the effectiveness and efficiency of the Joint Force Air Component Commander. Based on lessons learned from earlier efforts within the program, it was noted that as observation, orientation, decision, and execution times are driven toward progressively shorter timelines, the control of dynamic phenomena within real-time operations becomes the key challenge to practical implementation of any new generation of C2 systems. The emphasis for this program has therefore shifted toward the entire air operations enterprise, expanding and understanding the theories, models, technologies, architectures and concepts that can manage the dynamic effects of large scale, highly agile command and control systems. JFACC will develop and validate new C2 architectural concepts and appropriate control strategies with the ability to: (1) rapidly and efficiently respond to varying objectives and guidance, time constraints, changeable resources, erratic hostile responses, asymmetric threats and unpredictable anomalies (Agility); (2) proactively manage destabilizing events, such as time critical targets, while simultaneously avoiding undesirable long-and short-term effects, to include disruptive and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

inefficient impacts on downstream plans and operations (Stability); (3) adapt to the wide spectrum of military conflicts and activities (Flexibility); (4) provide feedback with reliable performance assessments at the level of abstraction and integration that allows decision makers to make effective decisions (Visibility); and (5) drastically reduce the required number of personnel and physical facility footprints for each C2 node (Cost and Vulnerability). This extension and application of theoretical techniques and tools for the analysis, synthesis, and execution of real-time dynamic control includes these unique technical challenges: (1) a hybrid of symbolic and continuous control and feedback signals (representation of operations); (2) control of nested, dynamically changing execution elements (structural and spatial changes in engaged and supporting forces); (3) predictive, reflexive, and generative state estimation with input and feedback signal ambiguities (decisions and assessments with uncertain and incomplete information); (4) hybrid and distributed control system architectures (centralized, de-centralized, self-organizing, etc.); (5) system control with dynamic counteracting disturbance signals (an active adversary); and (6) complementary human and machine control signals (mixed human/machine decisions).

(U) With the growing dependence on information systems and the pressing need to be able to get the right information to the right person at the right time, it becomes critical to deliver and protect information and assure the availability of associated services -- particularly in a stressed environment. Information Assurance (IA) technologies will be integrated into future versions of the Defense Information Infrastructure (DII) to provide a robust architecture across a wide range of DoD information systems. The development and fielding of secure information systems will be a continuing process of development and upgrading of existing systems and capabilities. The program is developing and refining information security technology into DII architectures and testbeds. As part of the program, the IA project is beginning to build a science and engineering discipline base for information assurance. One hypothesis to be tested is whether it is possible to create trustworthy systems from innovative integration of relatively untrustworthy mechanisms. The resulting security framework will reduce information vulnerability, allow increased interoperability and functionality, and provide the operational commander greater assurance that he will have the information he needs when he needs it. The initial investment provides near term applications to provide a modest level of protection, and a mechanism to test advanced secure information development in an end-to-end environment.

(U) A new generation of collection systems will provide dramatically increased volumes of higher fidelity data to the operational decision-maker. The challenge will be to dynamically manage and synchronize this advanced collection architecture with the next-generation processing, exploitation, and dissemination capabilities to provide the critical information to the decision-maker in the constantly changing operational situation. The Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM) program will expand on efforts begun under the Joint Force Air Component Commander (JFACC) program and provide the technical foundation for ISR support to Joint Vision 2010 through the development of Collection Strategy Development, and Multi-asset Synchronization capabilities to dynamically optimize/synchronize, schedule, and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

task the spaceborne, airborne and ground based collection, processing, exploitation and dissemination architecture. The AIM program will optimize ISR support to precision engagement and dominant maneuver by providing proactive information support to the warfighter, continuous integration of Operations and ISR, responsive ISR timelines, optimal ISR confederation management, and synchronization of ISR asset and exploitation tasking. AIM will insure near-real-time (NRT) information support to commanders and the Joint Task Force (JTF) by providing all echelons with: a common view of the collection environment; current status of collection, processing, exploitation, and dissemination operations; faster than real-time simulations in support of trade-off decisions; and the ability to conduct real-time multi-echelon coordination and shared decision making. The AIM Collection Strategy Development effort will interoperate with future automated operational plan representations to continuously accept and decompose ISR requirements into discrete sensor and exploitation tasks. AIM's Multi-Asset Synchronization effort will simultaneously plan and integrate platform routes and schedules that maximize the total information value from the ISR confederation in support of the operational plan. The AIM program will develop or advance technologies in the following areas: automated reasoning, mathematical programming, and cognitive representations. Resulting AIM capabilities will transition to DoD automated planning and C4ISR migration systems as appropriate.

(U) The Control of Agent-Based Systems Program will develop scaleable control strategies that enable intelligent software assistants for warfighters allowing them to delegate tasks such as information gathering, logistics supply, and operations planning that can be automated, but currently overload military personnel. Unlike other software, agents reduce the user's workload by operating autonomously and using available information to make intelligent decisions on behalf of the user. Agents are cost-effective; adaptive to new users, tasks, and computing environments; and collaborate with other agents on the network to solve problems. Agents also support a new lightweight approach for connecting dissimilar applications that don't speak the same language, but could be dramatically more powerful by sharing data and algorithms. The Control of Agent-Based Systems Program will develop control strategies and an interoperability tool to ensure heterogeneous agent systems work correctly and predictably in the evolving Defense Information Infrastructure. This tool will be employed as a basis for agentization of military legacy systems.

(U) Project Genoa is developing tools and a prototype infrastructure for collaborative crisis understanding and management for the national security community ranging from the National Command Authorities to Commanders of the Unified Commands. The growing transnational threats increase the need for early crisis discovery and mitigation. The earlier a crisis situation is discovered, identified and understood at the National Command Authority level, the easier it is to arrive at preemptive or mitigating strategies. The objectives are to: (1) decrease decision cycle time from days to hours by reducing the time it takes to go from detection of a problem to completion of a thorough briefing with actionable options for the decision maker; (2) increase number of situations that can be managed simultaneously by an order of magnitude because with the increasing number of potential crisis situations and reduced resources we must make analysts more efficient, cover more situations and provide more diverse options; and (3) reduce number of military deployments. The key enabling technologies are: knowledge discovery of critical information from

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

unstructured multimedia sources; structured argumentation to capture and present reasoning from evidence to conclusion; and a comprehensive corporate memory which will enable comparison of critical information across situation, time, and organization. Genoa will use technologies from other DARPA programs such as Information Assurance as well as commercial technologies. The current clients for components of the prototype system are Commander in Chief Pacific (CINCPAC) and Director Defense Intelligence Agency (DIA). This project was initiated and budgeted in PE 0602702E, Tactical Technology, Project TT-03, but as it has evolved, it transitioned to CCC-01 in FY 1999 and FY 2000, and will transition as Phase II to ST-28 in FY 2001 to focus specifically on the asymmetric threat environment.

(U) The Active Templates (AcT) program will produce a robust, lightweight software technology for aiding in the automation of detailed planning and execution for military operations using a plan spreadsheet metaphor. Active Templates are distributed data structures whose variables will be linked to live data feeds or problem-solving methods. Active Templates will assist with automated planning and execution by capturing, improving and updating critical information such as current state, goals, constraints, alternative actions, standard defaults, decisions in context, and rationale. Active Templates will be designed to be user-tailorable, networked, noise-tolerant, user-supported, and scalable and widely adopted. As a result, the technology to be fielded will provide faster plan generation (6 times), improved plan quality (8 times more options considered), 60 percent reduction in staff-hours required to track and coordinate missions, enhanced ability to capture lessons learned, and improved national capability to respond in a crisis.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Joint Force Air Component Commander (JFACC). ($ 27.403 Million)
  - Evaluated JFACC program results to date and lessons learned. Identified the critical need for new enterprise control techniques to provide system agility, stability, and responsiveness required for dynamic, real-time military operations.
  - Restructured the program focusing on the agile and stable control of military operations. Established a new JFACC Team of performers in line with program restructuring.
  - Establish an experimentation laboratory.
  - Developed object-based semantics for distributed operations and demonstrated its utility via a set of interoperability experiments.
  - Transitioned several JFACC-developed technologies into Service weapons systems and commercial markets.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

- Information Assurance. ($ 20.818 Million)
  - Demonstrated automated capabilities to limit system access, protect data, manage replication and recovery, provide advanced detection and response to intrusions, anti-flooding techniques, and reconstitute/ reconfigure information services to reflect dynamic operational priorities.
  - Demonstrated capability to do integrated monitoring of network service data, detected intrusion status and configuration/ reconfiguration; manage allocation of components and resources dynamically to reconstitute critical functions that have been degraded.

- Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM). ($ 9.550 Million)
  - Developed prototype AIM tools for information management, strategy development, and multi-asset synchronization.
  - Conducted data collections at the Defense Collection Coordination Center (DCCC) during the Kosovo crisis to support component development.
  - Exercised the Multi-Asset Synchronizer (airborne imagery intelligence (IMINT)) Joint Expeditionary Force Exercise (JEFX) '99.

- Control of Agent-Based Systems. ($ 13.365 Million)
  - Developed a framework to facilitate the integration, interoperability, and collaboration of heterogeneous systems between agents, object-based services and applications, and devices to assist information gathering and enhance military planning capabilities.

- Project Genoa. ($ 11.163 Million)
  - Project Genoa began user evaluation of selected components to establish performance metrics relevant to crisis situations. These experiments included initial knowledge discovery, structured argumentation, and argument presentation tools.
  - Components of the prototype system were installed at the DARPA test site for remote access by CINCPAC, DIA and other national security components for these user experiments and evaluations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

(U) **FY 2000 Plans:**

- Joint Force Air Component Commander (JFACC). ($ 27.964 Million)
  - Develop a reconfigurable model that simulates the dynamic phenomena within the military air operations enterprise. Using the enterprise model, identify the dynamic behaviors within military air operations, which must be stabilized by the application of innovative control strategies.
  - Experimentally investigate the stability effects of new control technologies and C2 architectures incorporated within the air operations enterprise model.
  - Validate the feasibility of a 10-fold reduction in the time to initiate a required change in operations, with accurate understanding of side and downstream effects.

- Information Assurance. ($ 36.898 Million)
  - Demonstrate automated capabilities that enable dynamic, secure collaboration between enclaves including data and invocation flow rules.
  - Demonstrate real-time, finer-grained advanced attack detection and response at the application layer, operating system, and network infrastructure. Couple advanced attack detection capabilities with automated system security and administration tools to enhance integrated monitoring and control of network services, detected attack status, and system configuration.
  - Dynamically and automatically manage allocation of components and resources to reconstitute critical functions that have been degraded.
  - Demonstrate security policy interoperability between enclaves. Explore Knowledge Base approach to adaptive systems management. Improve assurance measurement and risk analysis by establishing value functions for user data.
  - Enhance object assurance granularity by augmenting Common Object Request Broker Architecture Security (CORBASEC).
  - Complete selection of basic Information Assurance Science and Engineering Tools (IASET) architecture for incorporation into an integrated design environment.
  - Conduct initial IASET experiments with information assurance design methodologies emphasizing the application of science-based metrics in assessment activities.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

- Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM). ($ 7.799 Million)
  - Demonstrate dynamic replanning capabilities within the Battlespace Commander's Component during the Joint Expeditionary Force Exercise (JEFX) '00 exercise.
  - Develop collection, exploitation, and dissemination strategy optimization techniques and demonstrate during JEFX '00 in a standalone evaluation.
  - Transition initial automated collection strategy tools to the Integrated Collection Management efforts in the Defense Intelligence Agency and the Joint Staff.

- Control of Agent-based Systems. ($ 15.874 Million)
  - Develop and demonstrate a flexible information infrastructure and an interoperability tool called the Agent Grid, which will support the dynamic deployment of complex applications for dynamic domains such as military command and control. These super applications require the composability, adaptability, and autonomy provided by software agents interoperating in dynamic, mixed-initiative teams with human users. The Grid will provide access to shared protocols and ontologies, mechanisms for describing agents' capabilities and needs, and services that support interoperability among agents at flexible levels of semantics distributed across a network infrastructure.

- Project Genoa. ($ 11.759 Million)
  - In Project Genoa under knowledge discovery develop and implement information extraction from text and extensive use of intelligent agents, in structured argumentation refine crisis models and develop collaborative option generation, continue work on meeting transcription and develop ability to navigate and play back corporate memory.
  - Implement products from Information Assurance project so that a multi-intranet system may operate at mixed security levels. Continue evaluation by users from the national security community.

- Active Templates. ($ 7.839 Million)
  - Develop and encode templates of standard operating procedure, which integrates causal model capability to show how constraints, event triggering, inference, and uncertain reasoning can be utilized for fast crisis planning and execution.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

(U) **FY 2001 Plans:**

- Joint Force Air Component Commander (JFACC). ($ 18.000 Million)
  - Through further development of dynamic control technologies and C2 architectures, and experimentation using the air operations enterprise model, validate the feasibility of a 10-fold reduction in the disruptive side effects and downstream effects due to a required operational change (in addition to previous reductions in decision cycle time).
  - Initiate development of selected component prototypes to experimentally validate the viability of the new concepts and strategies.

- Information Assurance Science and Engineering Tools. ($ 21.000 Million)
  - Develop security-enabling technologies for autonomous software agents that allow agents to function across information system boundaries meeting requisite science-based surety standards.
  - Conduct a series of mini-experiments to foster the initial incorporation of developments in IA sciences, mathematics, and metrics into a set of design and assessment tools.
  - Use experiment results to strengthen the development of the basic architecture into an integrated design environment.

- Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM). ($ 8.000 Million)
  - Conduct operational evaluation of AIM automated collection strategy development and multi-asset synchronization technologies at Special Project 2001.
  - Transition multi-asset synchronization and automated collection strategy development tools to the Discoverer II program office and classified ISR management systems.

- Control of Agent-based Systems. ($ 12.000 Million)
  - Demonstrate agent technologies and tools in a military scenario that enables the run-time integration and interoperability of software components such as legacy applications, objects, and agents – into super applications customized to target present and future command and control problems.
  - Commence transitioning of CoABS developed technologies and tools for specific integration into Agent Markup Language and Taskable Agent Software Kit programs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

- Active Templates. ($ 10.000 Million)
  - Integration and demonstration of multiple templates merging by users to update information, add dependencies, and attach problem-solvers.

- Project Genoa Applications. ($ 1.787 Million)
  - Continue Phase I Genoa development and application activity towards transition.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Sep 99	Integrate a basic Public Key Infrastructure certificate management system to support basic security services. Demonstrate coordinated dynamic defense. Demonstrate basic replication techniques and anti-flooding techniques (port filtering).
Sep 99	Release initial Active Template toolbox with symbolic spreadsheet interface and parameterized problem-solvers.
Sep 99	Demonstrate multi-asset synchronization (airborne imagery intelligence (IMINT)) component at Joint Expeditionary Force Exercise (JEFX) '99.
Nov 99	Framework for the JFACC air operations enterprise model established as the baseline for experimentation and evaluation of new control technologies and C2 architectural concepts.
Jun 00	Demonstrate collaboration in multi-agent systems developed without hard-coded interfaces.
Sep 00	Demonstrate AIM automated collection strategy development and multi-asset planning at JEFX '00.
Jun 00	Initial JFACC experiments accomplished, using the air operations enterprise model, to assess the contribution of theoretical techniques and tools toward control of air operations, including response times and level of understanding of enterprise dynamics.
Jul 00	Demonstrate modular combined arms execution toolkit and small unit synchronizing toolkit.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

Jul 00	Demonstrate Knowledge Base approach to systems management.
Jul 00	Demonstrate user data value functions.
Jul 00	Demonstrate rapid knowledge discovery and structured argumentation in crisis management.
Sep 00	Demonstrate augmented CORBASEC. Demonstrate composable trust systems.
Sep 00	Demonstrate secure enclave-to-enclave collaboration. Demonstrate advanced intrusion detection and response capability integrated with dynamic system monitoring, control, and restoration.
Sep 00	Demonstrate semi-automated templates handling incomplete data amidst 100 execution changes in a military exercise.
Sep 00	Demonstrate Advanced ISR (Intelligence, Surveillance, and Reconnaissance) Management (AIM) automated collection strategy development and multi-asset planning Joint Expeditionary Force Exercise (JEFX) '00.
Dec 00	Demonstrate tools for analysis of IW attack costs.
Dec 00	Demonstrate system recognition of malicious code.
Feb 01	Experimental evaluation of JFACC-developed theoretical control techniques and tools completed, incorporating them into the final enterprise model. Validate the reduction in both time and disruptive effects to the air operations enterprise. Identify most promising C2 architecutural concepts, control strategies, and components for further validation.
Mar 01	Initiate development of selected components from new JFACC C2 architectural concepts and control strategies.
Mar 01	Demonstrate dynamic policy adjustment.
Jun 01	Demonstrate agents that dynamically create software interfaces; define scalability limitations.
Jul 01	Demonstrate CINC to tactical level integrated combined arms execution command and control with small unit synchronizing toolkit.
Sep 01	Demonstrate prototype adaptive security system and prototype DII I&W system.
Sep 01	Conduct evaluation of AIM's automated collection strategy development and dynamic multi-asset synchronization tools at Special Project '01.
Sep 01	Demonstrate augmented DCOM and JAVA RMI.
Sep 01	Demonstrate that users can tailor their own templates, update information, add dependencies, and attach problem-solvers. Show that active template technology is scalable in that 50 templates have been built. Show that planning speed doubles and plan quality improves.
Jun 02	Demonstrate agent-based software technology for creating "super-applications" at run time.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-01

Dec 02	Operational evaluation of integrated AIM capabilities for dynamic and proactive optimized collection strategy development, multi-asset synchronization for execution of the selected collection strategy, and continuous collaboration between operations and ISR.
Sep 02	Show six-fold increase in execution replanning using Active Templates attached to live data feeds from battlefield sensors.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Information Integration Systems CCC-02	87.071	114.755	69.593	39.749	32.246	35.012	35.837	Continuing	Continuing

(U) **Mission Description:**

(U) The goals of the Information Integration Systems project are to take diverse inputs, including those planned as outputs, from the PE 0603762E Sensors and Exploitation Systems project (SGT-04), and perform distributed and dynamic all-source correlation and fusion to produce an integrated, geo-spatially referenced, battlefield database and knowledge-base, and through the use of wideband dissemination and integrated sensor management allow multi-site, real-time, collaborative situation assessment and course-of-action evaluations. These goals are being addressed by the Dynamic Database (DDB) program, the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD), the Airborne Communications Node (ACN) program, the Command Post of the Future (CPOF) program, the UltraLog program, and the High Frequency, High Bandwidth program (HFHBP).

(U) The overarching goal of the Dynamic Database (DDB) program is to continuously produce significant battlespace information from immense quantities of multi-sensor data in a manner responsive to a diverse user community. More specifically, the DDB program will design, build, and demonstrate a system that (1) provides ready access to all battlespace sensor observations collected over time, (2) uses the resulting sensor history to identify and focus users' attention on tactically significant battlespace events, and (3) shares and synchronizes local situation changes across the distributed battlespace. Dynamic Database contents will be maintained and shared through a Sensor History Database (SHDB) that integrates geo-registered sensor history data with terrain, and potentially environmental, and force information to yield a logically consistent, multi-level view of the battlespace. Single and multi-sensor data fusion approaches will be developed that efficiently update the SHDB by filtering tactically significant changes from the Dynamic Database sensor history. This objective includes the development of theory and techniques for incorporating mission and situation context into low-level processing algorithms, and advanced phenomenology models for translating expected conditions and behaviors into multi-sensor observables. Significant situation changes will be shared throughout the battlespace within a scaleable Dynamic Database (DDB) enterprise of distributed Sensor History Database (SHDB) nodes, computing applications, processors, and information repositories. DDB enterprise technologies will be developed to monitor database conditions for change, trigger external processes when conditions meet posted criteria, propagate changes across DDB nodes, and support queries and searches of distributed databases.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

(U) The objective of the Battlefield Awareness and Data Dissemination (BADD) Advanced Concept Technology Demonstration (ACTD) is to integrate and demonstrate information management and battlefield awareness technologies that allow operational users to easily access and exploit an expanded, massive information flow, and for commanders to manage it. This operational prototype service will allow commanders to design/ tailor their own information environment, and provides access to key transmission mechanisms and worldwide data repositories. Achieving battlefield awareness means getting the information to those who need it, ready-to-use, in a timely and cost-effective manner. BADD implements this vision by supplying the warfighter with a description of the battlespace tailored to their mission needs by intelligent selection of information to be broadcast/delivered (e.g. Global Broadcast Service (GBS), broadband DISN and selected tactical networks), as well as intelligent processing of user requests (pull) and filtering at the warfighter workstation so that relevant/needed information is available. BADD will be evaluated through participation in a series of collaborative assessments, demonstrations, and a military utility assessment. BADD is working in concert with the Defense Information Systems Agency (DISA) to provide GBS with advanced information management capabilities and new applications as part of the overall transition plan of BADD developments to operational users after test and evaluation in the ACTD. Selected applications and dissemination services will be transitioned to the Defense Information Systems Agency (DISA) for incorporation into the Defense Information Infrastructure Common Operating Environment (DII/COE).

(U) The Phase III (Technology Improvement) phase of BADD has been renamed the Agile Information Control Environment (AICE). AICE will focus on developing and demonstrating breakthrough information management technologies that provide 10 times improvement in the efficient and timely delivery of information; that extend current information management services to support time critical and real-time information flows (e.g., sensor to shooter); and that optimize information flows based upon maximizing the value of information delivered vs. today's practice of maximizing the volume of data delivered. AICE services enable oversubscribed information resources to deliver maximum information value to users, in accordance with variable mission objectives. To successfully demonstrate the operational payoff of these capabilities, AICE will develop a prototype MetaNet that provides end-to-end quality of service across multiple tactical and commercial-based networks. AICE will also develop an Adaptive Information Controller that optimally allocates the resources of shared information infrastructure (networks, servers, guards, etc.) based upon overall operational concerns. AICE will develop Information Policy Management Tools that enable a commander of a large military enterprise to create, establish and maintain an enterprise wide specification of information flow priorities. AICE will also develop a unifying theoretical basis for characterizing and measuring the performance of Adaptive Information Control components. Performance Analysis and Integration experiments will be conducted to integrate and measure the performance of AICE components via a series of experiments that utilize the theoretical basis developed.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

(U) The Airborne Communications Node (ACN) program will provide a multifunction payload deployable on an airborne platform that demonstrates for the first time that a single communications node can interconnect, much beyond current radio range (beyond line of sight and horizon), more than 70 different channels and 17 waveforms. This capability will provide tactical units with direct access to over-the-horizon communications capability and continuous broad area communications coverage over the battlefield, with cross-system connectivity amongst on-the-move warfighters – to include Joint and Coalition forces - significantly improving rapid force projection, synchronization and synergy. To connect isolated and rapidly maneuvering forces via high data rate communications, provide reach-back connectivity to CONUS from forward elements, allow gateway connectivity among dissimilar radios and support secure channel-based dynamic configuration control requires the development of a system capable of providing reliable service in a severe EMI and jamming environment. This is achieved through the development of a highly flexible, software reprogrammable radio communication system that incorporates a complex cosite mitigation approach. A prototype payload is being developed to be supportable on a Global Hawk High Altitude Endurance unmanned airborne vehicle, but the system is designed to be flexible and scalable to any airborne platform, including tactical UAVs and manned platforms, for rapid deployment, thus enhancing the existing legacy communications capability, providing new commercially-derived services (i.e., cellular) and enabling support for the small unit operations and mobile command centers of the future. The Airborne Communications Node program will integrate Warfighter Internet functionality to support Internet-like communication services across multiple airborne nodes. The program will conclude with field demonstrations in FY 2002.

(U) The objective of the Command Post of the Future (CPOF) program is to improve the speed and quality of command decisions, more effectively disseminate command decisions, and reduce the number of staff members required to process and manage the information systems required to do so. Three important command functions will be addressed in order to achieve this objective: 1) improved speed and quality of situation awareness; 2) improved speed of course of action (COA) development and selection; and 3) improved clarity of COA communication between commander and subordinates. For each of these command functions, CPOF is developing technologies that leverage the expertise of the commander by exploiting and augmenting natural cognitive abilities. The approach is to provide a very intuitive, well integrated, decision-centered, information environment in which the commander and a few staff members can quickly understand the changing battlefield situation, select the best course of action (COA), communicate that COA to the implementing units, and monitor the execution. The key technologies to be developed are: (1) an integrated visualization environment where the commander and his staff can view immediately understandable presentations of the changing battlefield situation, presentations which are tailored to the situation and the command decisions of interest; (2) a powerful and comprehensive human-computer interaction capability (through speech and gesture understanding, language understanding, dialog management, and visual collaboration) so that the commander and his staff can successfully understand and explore the information environment, without requiring dozens of staff members to operate and integrate multiple information systems; (3) a command post dialog manager which would automatically track current activities and tasks in the command post to tailor the information presentations to topics of interest; (4) an integrated suite of knowledge

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

bases, intelligent agents, plan sentinels, information processing assistants which would automate many of the lower level staff functions and automatically invoke and operate supporting, planning and analysis applications; and (5) a modular, portable suite of hardware and software components that can be quickly configured and tailored to various command environments (stationary and mobile), at different echelons of command.

(U) Current logistics systems cannot efficiently manage their resources in the complexity and uncertainty of war. The purpose of the UltraLog initiative is to develop advanced information systems technology to support logistics planning, execution, and dynamic replanning during the complex, extremely fast paced, chaotic wartime environments where responses and reactions are required in terms of seconds and minutes vice the hours and days permitted during peacetime. UltraLog will develop technologies in three main focus areas: (1) complex penalty functions, dynamic system adaptation/reconfiguration, and multiple mode management; (2) advanced plan space management and automated process learning; and (3) radical architecture performance improvements, improved architecture level security, robust/fault tolerant network, and dynamic configuration capabilities.

(U) The goal of the High Frequency, High Bandwidth Program (HFHBP) is to exploit high data transmission at W-band (100Ghz) for ground-to-ground, ground-to-air, and ground-to-space communication applications. The increasingly complex demands of military operations and the thirst for more information require the capability to transmit and receive data at much higher rates than with existing systems. W-band may provide up to a factor of 100 increase in potential bandwidth over current fielded systems. In addition, system components (antennas, transceivers, etc.) have the potential for considerable size and weight savings compared to existing systems. Another added bonus may be a reduction in susceptibility to intercept at this frequency due to the much tighter transmission patterns. HFHBP will investigate systems aspects of 100Ghz-class communication and data systems as well as the development of specific components for such a system leading to actual field trails and demonstrations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Dynamic Database (DDB). ($ 23.633 Million)
  - Completed the initial DDB architecture design. Developed and conducted experiments of single-sensor entity phenomenology models.
  - Developed prototype multi-sensor target phenomenology models. Incorporated situation context into single and multi-sensor anomaly detection algorithms.
  - Demonstrated a prototype update service for the entity layer of the Dynamic Database.
  - Integrated technology products in the Dynamic Database (DDB) System Integration Laboratory (SIL) and demonstrated an initial DDB system capability that ingests raw multi-sensor data, aligns, and mosaics the data within a common 2-D spatio-temporal reference frame and provides the user ready access to sensor history data.
  - Conducted a multi-sensor data collection at the National Training Center in conjunction with the XVIII Airborne Corps 525th Military Intelligence (MI) Brigade. Sensor types included Synthetic Radar (SAR), Electro-optic (EO), Infrared (IR), Ground Moving Target Indicator (GMTI) Radar, and Signals Intelligence (SIGINT) from a mix of currently fielded and advanced technology sensors platforms. Data from this collection will be used to develop fusion algorithms and assess robustness of DDB technology.

- BADD ACTD. ($ 10.842 Million)
  - Deployed Battlefield Awareness and Data Dissemination (BADD) software to PACOM and began the operational utility assessment. Integrated the BADD software with the DISA Information Dissemination Manager (IDM) COTS/GOTS products in preparation for fielding to selected CINCS in 3d Qtr FY 00. Initiated formal segmentation of the BADD/DISA products for integration into the Defense Information Infrastructure (DII) Common Operating Environment (COE) and the Global Command and Control System (GCCS). Delivered the battlefield Awareness video archiving tools to the Joint Staff Service Center (JSSC) for installation and CINC utilization. Conducted four collaborative assessments with operational users at multiple agencies/distributed service sites (Army, Navy, Air Force, Special Operations Force (SOF) and Joint). Established a working relationship with the SOF community to determine how these capabilities could rapidly be integrated into SOF operations. Begin the two-year ACTD sustainment phase. Have operational pilot services at SPAWAR San Diego, Hurlburt AFB, FT Gordon, ACOM, Joint C4SIR Battle Center (JBC) and CECOM.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

- AICE. ($ 19.460 Million)
  - Theoretical Framework and Metrics: Developed comprehensive AICE Functional Architecture baseline. Coordinated, standardized and documented all major interfaces in AICE. Developed performance assessment methodologies and metrics to permit controlled scientific evaluation of AICE technologies. AICE Technology Development: Developed AICE technology components which span the AICE Functional Architecture. Began developing prototype MetaNet consisting of tactical networks (MSE, CEC, and LINK16), DISN networks, and commercial networks. Developed information channel building and instantiation of information channels on commercial ATM and military UHF SATCOM networks with mission-driven quality of service. Began development of information flow optimization technologies for global, content-based information utility maximization. Developed formalism for hierarchical resource allocation policy expression and resolution against mission objectives. Developed a generalized specification of the metadata attribute space over which policies are applied. Developed the multi-dimensional vectorspace-based algebra required to achieve other AICE technical goals. Performance Assessment and Integration: Developed Performance Assessment Environment and defined experiments to evaluate and spur improvement of AICE technology components. Developments supported AICE component Build 1.

- Airborne Communications Node (ACN). ($ 21.933 Million)
  - Initiated the design, development, and integration the proof-of-concept payloads (three system design teams).
  - Continued ACN technology integration and experimentation, and conducted lab demonstrations to verify mitigation approaches/designs for high-risk areas such as electromagnetic interference (EMI)/cosite and antenna coupling/range.

- Command Post of the Future (CPOF). ($ 11.203 Million)
  - Began development of CPOF technologies, an integration environment, and designed a series of decision experiments to test the effectiveness of the CPOF system to improve command decisions. Technology development in automated visualization, multi-modal interfaces, automated context tracking, and dialog management has begun. Detailed studies of mental models of command decision making have begun and first cut encoding of these models into a functional abstraction hierarchy (FAH) has started. A detailed system integration plan has been developed. Detailed experiment planning has begun with extensive interaction between the principal investigators (PIs), representatives from the battle labs (principally, the Marine Corps Warfighting Lab and the Army's Battle Command Battle Lab), and the CPOF senior advisory group made up of retired senior military commanders from all services. Development of the first version of the CPOF integration environment is underway.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

(U) **FY 2000 Plans:**

- BADD ACTD. ($ 7.418 Million)
  - Complete the integration effort with DISA's products. Field BADD/DISA products to selected CINC's six months prior to the end of the ACTD. Continue upgrading capability (based on warfighter input/feedback) to provide a more enhanced version to the CINC's in the latter part of the FY. Provide interfaces that will allow other ACTDs and programs to take advantage of the BADD capabilities. Upgrade the software to be compliant with the DISA next iteration of the DII COE. Conclude transition period and end the ACTD. Handoff capability to DISA for O&M support.

- AICE. ($ 23.391 Million)
  - Complete the development of metadata vectorspace-based algebra and use it to develop dynamic and conditional information profiling capabilities. Continue development of advanced information management technologies: Develop large-scale dynamic channel building algorithms and global quality-of-service optimization for variable utility channel requests. Extend information management services to multiple policy governing hierarchies and moving entities. Demonstrate prototype MetaNet providing end-to-end quality of service across tactical, DoD DISN and commercial networks, including wireless Internet Protocol (IP) and Mobile Subscriber Equipment (MSE) networks. Begin investigation of incorporating ACN as part of the MetaNet. Develop model-based forecasting capability to enable commanders to assess the consequences of candidate policies prior to their activation. Performance Assessment and Integration: Conduct assessment and analysis of AICE Build 1 technology components. Develop requirements for and conduct component integration into Performance Assessment Environment. Developments support AICE component Build 2.

- Dynamic Database (DDB). ($ 24.397 Million)
  - Complete a refined DDB architecture design that prototypes a single node DDB System Integration Laboratory (SIL). Expand the Sensor History Database (SHDB) object schema to include pedigrees that automatically map entity-level situation assessments to multi-sensor source data using data-driven fusion methodologies.
  - Extract and fuse enhanced multisensor data features over time. Include visible Electro-optic (EO) into the stored data-types. Develop and validate multiple-sensor terrain and entity phenomenology models. Validate prototype multi-sensor target phenomenology models.
  - Incorporate situation context into single and multi-sensor anomaly detection algorithms.
  - Demonstrate an interactive prototype update service for the entity layer of the Dynamic Database.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

- Explore alternative concepts for detecting/recognizing significant change and activity from multi-source data.
- Upgrade technology products in the DDB SIL. Demonstrate an interactive prototype DDB system that ingests raw multi-sensor data, aligns, mosaics, and displays the data within a common 3-D spatio-temporal reference frame, automatically identifies and cues the user to uncorrelated data features, updates the sensor history layer of the SHDB, and provides the user ready access to Synthetic Aperture Radar (SAR), Electro-Optic (EO), Infrared (IR), Ground Moving Target Indicator (GMTI) Radar, and Signals Intelligence (SIGINT) sensor history data registered to a common fiducial and entity-level situation hypotheses.

• Command Post of the Future (CPOF). ($ 25.684 Million)
  - The program will produce technology in the areas of automated visualization, multi-modal interaction (speech and gesture recognition), automated context tracking, dialog management, and cognitive modeling. In automated visualization, the results of the first experiments in cognitive visualization principles will be encoded in a knowledge base and tools for extracting and using these principles will be developed. In multi-modal interaction, tools for recognizing speech and 2D gesture interactions will be developed as well as higher order sketch understanding. These will provide the base for natural interaction between a commander and the CPOF system. Automated context tracking will encode the mental models captured in the functional abstraction hierarchy (FAH) and develop technologies for isolating and tracking cues for indexing the FAH. Cognitive modeling will continue development and refinement of the command decision making mental models and encode them in the FAH. The first series of limited objective experiments (LOEs) will be completed and a comprehensive experiment will be run in conjunction with a major warfighting experiment. Program will also explore architecture technologies developed by the Advanced Logistics Project to develop and experiment with alternative approaches to goal selection using complex information representations and emerging parallel information evaluation techniques to improve management and responsiveness of the wartime logistics infrastructure. The second phase of experiments will be designed and a number of the phase 2 LOEs will be run. The integration environment will be complete and individual technology components will be added.

• Airborne Communications Node (ACN). ($ 33.865 Million)
  - Conduct proof of concept manned aircraft demonstrations of competitive ACN system designs.
  - Down select to a single team for full function payload design and development. This design will be targeted to operate within the stringent environment of the Global Hawk high altitude endurance unmanned aerial vehicle, thereby stressing the packaging technology required to meet the form, fit and function. The payload will be developed using a modular and scalable design, which will enable subsets of the full functionality and design to be easily transferred to other SWAP-limited platforms like tactical UAVs.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

- Complete final system designs and begin payload integration.
- Conduct laboratory demonstrations of critical subsystems (e.g., interference mitigation subsystem).

(U) **FY 2001 Plans:**

- AICE. ($ 17.193 Million)
  - Demonstrate the capability to support real-time information flows across the MetaNet. Develop mechanisms for visualizing and understanding the macro structure of information flows supporting a large military operation. Enhance robustness to outages and demonstrate scalability to service 10,000's of information channel requests by users, 1,000's of information sources and 100's of commanders. Automate the generation of information management policies based upon commander's intent including situation-based forecasting support. Performance Assessment and Integration: Conduct assessment and analysis of AICE Build 2 technology components. Developments support AICE component Build 3. Assess military utility of AICE Build 3 services. Transition into pilot service and/or operational environments.

- Dynamic Dababase (DDB). ($ 4.000 Million)
  - Extend database query services to include rapid access to all levels of situation information in response to pre-defined user profile requested content-based index and query capabilities.
  - Continue to upgrade technology products in Dynamic Database (DDB) System Integration Laboratory (SIL). Demonstrate an interactive prototype DDB system that ingests raw multi-sensor data, aligns, mosaics, and displays the data within a common 3-D spatio-temporal reference frame, automatically identifies and cues the user to uncorrelated data features, updates the sensor history layer of the Sensor History Database, and provides the user ready access to Synthetic Aperture Radar (SAR), Electro-optic (EO), Infrared (IR), Ground Moving Target Indicator (GMTI) Radar, and Signals Intelligence (SIGINT) sensor history data registered to a common fiducial and both entity and force level situation hypotheses.
  - Incorporate Dynamic Database (DDB) technology into the XVIII Airborne Corps, 525th Military Intelligence Brigade, and Forward Sensor Enclave testbed.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

- Command Post of the Future (CPOF). ($ 22.000 Million)
  - The program will continue to develop and integrate new CPOF technology into a complete CPOF system to enable commanders to improve the speed and quality of command decisions to stay ahead of the adversary's ability to react. New versions of the technology components developed in FY 1999 will be integrated and tested in a series of simulation-based decision experiments. The most effective technology will be integrated into a complete CPOF system for an end-to-end demonstration of in a simulated joint exercise. Preparations will begin for an operational demonstration of the CPOF system in a joint field exercise in FY 2002.

- Airborne Communications Node (ACN). ($ 13.400 Million)
  - Complete full system integration and extend laboratory demonstrations across multiple subsystem components.
  - Plan and execute extensive ground interaction demonstrations with joint warfighters.

- UltraLog. ($ 10.000 Million)
  - Demonstrate and evaluate the first phase of the results from the theoretical investigation into advanced goal selection and dynamic adaptation techniques in the enhanced architecture.
  - Explore incorporation of machine learning techniques to allow dynamic adoption of business processes based on interaction with the users.
  - Extend advanced algorithms for manipulation of complex functions for feedback and control; develop algorithms for efficient buffer zones and system interaction between different intensity business processes; test cluster failure detection techniques under various failure modes; test interaction of concurrent feedback algorithms.
  - Provide limited demonstration and evaluation in the problem domain of an Air Expeditionary Force and associated logistics infrastructure establishment.

- High Frequency, High Bandwidth (HFHBP). ($ 3.000 Million)
  - Initiate miniaturization of 100GHz components.
  - Assess propagation characteristics in hostile terrain.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Dynamic Database:	
Dec 99	Demonstrate an interactive DDB multi-sensor history database and entity-level situation assessment service (extending the services to include Electro-Optic (EO)).
Oct 00	Incorporate Dynamic Database DDB technology into XVIII Airborne Corps 525th MI Brigade Forward Sensor Enclace (FSE) Testbed.
Jun 01	Demonstrate an interactive DDB system that ingests raw multi-sensor data, aligns, mosaics and displays the data within a 3-D Spatio-temporal reference frame in the System Integration Laboratory (SIL).
Battlefield Awareness And Data Dissemination:	
Sep 99	Install BADD service at PACOM.
Apr 00	Field BADD products to selected CINCs.
Nov 00	Complete Military Utility Assessment of BADD.
Sep 00	Complete BADD ACTD transition to DISA and the Services.
Agile Information Control Environment:	
Oct 99	AICE Performance Assessment Environment operational.
Dec 99	Complete AICE Build 1 Technology Component Assessment.
Apr 00	Complete AICE theoretical framework.
Sep 00	Demonstrate AICE prototype MetaNet.
Dec 00	Complete AICE Build 2 T Component Assessment.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Command, Control and Communications Systems PE 0603760E, Project CCC-02

Sep 01 Demonstrate real-time flow support, AICE MetaNet.
Sep 01 Complete AICE technology transition into pilot service or operational environments.

Airborne Communications Node:
Dec 99 Complete initial ACN System Design Reviews and conduct proof of concept flight demonstrations.
Jan 00 Complete final Phase 1 ACN System Design Reviews and proof-of-concept flight demonstrations.
Mar 00 Downselect to one ACN Team.
Jul 01 Complete ACN Payload Integration, laboratory and antenna range tests.
Sep 01 Complete ACN performance testing and demonstration.

Command Post Of The Future:
Dec 99 Command Post of the Future integration environment tested and complete.
Aug 00 CPOF Comprehensive Experiment One run in conjunction with Advanced Warfighting Experiment (AWE).
Jul 01 CPOF Comprehensive Experiment Two to run at Fort Hood in warfighting experiment.
Sep 01 Demonstrate Course of Action (COA) level analysis within major Army exercises (e.g., Advanced Warfighter Experiment - AWE).

Ultralog:
Sep 01 General Notional Wartime Logistics Demonstration.

High Frequency, High Bandwidth:
Mar 01 Assess propagation characteristics in hostile terrain.
Jun 01 Initiate miniaturization of 100 GHz components.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Communication and Simulation Technology PE 0603761E			

COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	49.988	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Advanced Simulation CST-01	24.596	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A
Global Grid Communications CST-02	25.392	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) Mission Description:

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because its purpose is to demonstrate and evaluate advanced simulation technologies and networking systems that will seamlessly integrate command and control functions needed for future global defense operations. The activities funded are being transitioned to the Services after FY 1999.

(U) The Advanced Simulation project is developing advanced simulation technologies that provide seamless synthetic battlespace that will enable high fidelity simulation across a full range of DoD functions. Funded within this project are the Synthetic Theater of War (STOW) Advanced Concept Technology Demonstration (ACTD) program and the Advanced Simulation Technology Thrust.

(U) The Global Grid Communications project is developing and demonstrating advanced networking technologies needed for global defense operations in the 21st century. The three main efforts in this project are: (1) the Joint Task Force Advanced Technology Demonstration (JTF ATD); a rapid Commander Joint Task Force (CJTF) crisis response capability for a range of situations capable of being established and operational in days; (2) the Warfighter's Internet program, a mobile wireless backbone communications network; and (3) the Broadband Information Technology (BIT) program which seeks to develop all-optical multiple wavelength transmission and networking technologies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Communication and Simulation Technology PE 0603761E

(U) **Program Change Summary:** (*In Millions*)

	FY1999	FY 2000	FY 2001
Previous President's Budget	52.258	0.000	0.000
Current Budget	49.988	0.000	0.000

(U) **Change Summary Explanation:**

FY 1999 Decrease reflects reprogramming for SBIR and minor repricing.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Communication and Simulation Technology PE 0603761E, Project CST-01				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Advanced Simulation CST-01	24.596	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) The strategic environment in which the United States operates will require Joint Forces to operate across the full spectrum of conflict. At the same time, resources will continue to shrink, requiring the Department to search for the most cost effective means to perform the full spectrum of defense functions. To support the National Military Strategy, the Advanced Distributed Simulation (ADS) program is developing advanced simulation technologies that provide a seamless synthetic battlespace that will enable high fidelity simulation for Joint/Service readiness training and mission rehearsal. Within the ADS Programs the Synthetic Theater of War (STOW) Advanced Concept Technology Demonstration (ACTD) program is developing advanced simulation technologies that provide a seamless synthetic battlespace to support joint training and mission rehearsal activities. The STOW ACTD technology development includes Synthetic Environment, Synthetic Forces, System Design and Integration and Advanced Network components. These technologies are transitioning to Service and joint simulation developers at the end of FY 1999.

(U) The Advanced Simulation Technology Thrust (ASTT) program builds on the STOW Program and develops the advanced simulation technologies required to support the next generation of DoD simulation systems, such as the Joint Simulation system (JSIMS). The goal of the ASTT program is to solve the core technology problems required to significantly increase the flexibility of simulations while simultaneously reducing the requisite resources (cost, personnel and time). DARPA's ASTT technology development efforts complete in FY 1999.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- STOW ACTD. ($ 12.727 Million)
  - Continued to refine and transition prototype technologies in support of USACOM and the Services.
  - Demonstrated the representation of a seamless land/sea/air warfighting synthetic environment.
  - Completed the STOW ACTD and transitioned technology, tools and applications to the next generation of DoD simulations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Communication and Simulation Technology PE 0603761E, Project CST-01

- Advanced Simulation Technology. ($ 11.869 Million)
  - Transitioned high risk Advanced Simulation Technologies required by, and in coordination with, JSIMS and other Service simulations (e.g. WARSIM) to meet their respective Full Operational Capability (FOC) requirements.
  - Developed the algorithms to automatically translate exercise requirements into simulation requirements and to automatically compose the resulting simulation.
  - Created a scalable framework for modeling the C2 hierarchical and collaborative decision-making process to automatically generate and evaluate multiple courses of action.
  - Developed consistency algorithms to support the rapid editing of environmental data (pre-exercise & run time) while maintaining temporal and spatial consistency within and across all environmental domains.
  - Applied advanced latency reduction techniques and dynamic data distribution algorithms to achieve scalable architectures necessary to support large-scale distributed simulations.

(U) **FY 2000 Plans:**

- Not Applicable.

(U) **FY 2001 Plans:**

- Not Applicable.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Communication and Simulation Technology PE 0603761E, Project CST-01

(U) **Schedule Profile:**

Plan	Milestones
Sep 99	Complete the development, integration and documentation of the STOW prototype. Complete final transition of STOW Technology to JSIMS/JWARS and the military service.
Sep 99	Transition ASTT simulation technologies to the JSIMS and the Service simulation developments.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)					DATE September 1999			
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Communication and Simulation Technology PE 0603761E, Project CST-02				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Global Grid Communications CST-02	25.392	0.000	0.000	0.000	0.000	0.000	0.000	0.000	N/A

(U) **Mission Description:**

(U) This project develops and demonstrates advanced networking technologies needed for global defense operations in the 21st century. Network services will be developed in order to support geographically dispersed staff for crisis management and to support warfighters in rapid deployment, highly mobile scenarios. The program consists of three efforts: the Joint Task Force Advanced Technology Demonstration (JTF ATD), the Warfighter's Internet, and the Broadband Information Technology program. These technologies will transition to the Services at the end of FY 1999.

(U) The goal of the Joint Task Force Advanced Technology Demonstration (JTF ATD) is the development of rapid crisis response capabilities for the Commander Joint Task Force in support of a wide range of situations from Major Theater War (MTW) to Operations Other Than War. The JTF ATD will create a supportable, global grid-based C4I technology base that will deliver an exponential increase in decision support capability to the theater commander.

(U) The goal of a Warfighter's Internet is to expand open architecture and internetworking technologies into the mobile wireless domain to: provide a robust, automatically reconfigurable, internetworking capability; and, to support warfighters in rapid deployment and highly mobile scenarios. This will be accomplished as a joint effort with the Airborne Communications Node program and will enable a backbone communications network consisting of multiple airborne nodes which in turn connect to users and networks on the ground, on the ocean, and in the air.

(U) The Broadband Information Technology (BIT) program seeks to develop all-optical multiple wavelength transmission and networking technologies. Specifically, this program has four goals: (1) a billion bits per second bandwidth on demand, independent of the analog and digital nature of the applications, (2) rapid, nearly transparent reconfiguration of network routing, (3) multiplexing of continuous transmission rates (bit rates from thousands of bits per second to a billion bits per second), and (4) transmission of analog and digital signals in a single fiber.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Communication and Simulation Technology PE 0603761E, Project CST-02

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Broadband Information Technology. ($ 5.527 Million)
  - Demonstrated full operations, multi-wavelength, experimental, system network including interoperability among testbeds distributed across several geographic domains.

- JTF ATD. ($ 5.578 Million)
  - Delivered JTF ATD, developed composable services and provided infrastructure support to the Technology Integration Center (TIC) in this last year of the JTF ATD.
  - Moved the JTF ATD's integration and experimentation environments to the TIC. Extended and finalized the composable services system developers tools and transitioned the composable services and tools to the TIC repository.
  - Executed Technology Integration Experiments (TIEs) with several other DARPA projects and the Joint Logistics ACTD. In support of these activities, held several training sessions (boot camps) for prospective adopters of the composable services.

- Warfighter's Internet. ($ 14.287 Million)
  - Integrated technology with the Airborne Communications Node (ACN) project. In coordination with the Airborne Communications Node, initiated test & demonstration of airborne cross links, wireless backbone using manned aircraft; continued to develop network protocols and integrated into commercial products.
  - Demonstrated capabilities as part of combined ACN demonstration in late FY 1999.
  - Completed Advanced Digital Receiver technology development.
  - Completed RF MEMS Tunable Filter, programmable INFOSEC, advanced digital transmitter/external power amplifier and antenna technology developments.

(U) **FY 2000 Plans:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Communication and Simulation Technology PE 0603761E, Project CST-02

(U) **FY 2001 Plans:**

- Not Applicable.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Sep 99	Field demonstration of mobile wireless network technologies coordinated with Battlefield Awareness & Data Dissemination (BADD), Extended Littoral Battlespace (ELB) and Small Unit Operations experiments.
Sep 99	Complete Advanced Digital Receiver upgrades.
Sep 99	Deliver JTF ATD composable services and developers tools to the Technology Information Center (TIC) repository.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E				

COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	204.682	232.319	189.002	226.086	251.482	249.096	276.896	Continuing	Continuing
Guidance Technology SGT-01	32.878	21.466	22.340	22.633	32.964	33.764	36.564	Continuing	Continuing
Aerospace Surveillance Technology SGT-02	65.465	77.712	67.438	89.798	100.232	84.500	109.300	Continuing	Continuing
Air Defense Initiative SGT-03	24.430	42.350	23.471	19.960	30.000	38.000	38.200	Continuing	Continuing
Sensors and Exploitation Systems SGT-04	81.909	90.791	75.753	93.695	88.286	92.832	92.832	Continuing	Continuing

(U) <u>Mission Description:</u>

(U) The Sensors and Guidance Technology program element is budgeted in the Advanced Technology Development Budget Activity because it is developing the system oriented technologies necessary to enhance sensor and weapon system accuracy and capability to meet current and emerging threats. Four projects are funded in this program element: Guidance Technology, Aerospace Surveillance Technology, the Air Defense Initiative, and Sensors and Exploitation Systems.

(U) The Guidance Technology project is leveraging geolocation technologies to enhance the navigation and/or guidance packages of airborne platforms, ground vehicles and weapons. These improved systems will improve the accuracy and effectiveness of stand-off weapons, minimizing collateral damage while reducing the cost-per-kill.

(U) Aerospace Surveillance Technology programs are developing technologies to improve the accuracy and timeliness of surveillance systems in all weather, in hostile reception environments, and when necessary, in a covert manner. The programs funded by this project exploit recent advances in multispectral target phenomenology, signal processing, large constellation satellite architectures, high performance computing and low cost micro-electronics technologies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E

(U) The Air Defense Initiative is an on-going activity whose overall goal is to reduce the proliferating cruise missile threat and enhance the survivability of US assets in the face of enemy electronic countermeasures.

(U) The objective of the Sensors and Exploitation Systems project is to provide the warrior with situational awareness and battlefield dominance by developing key sensor technologies; providing near-real-time semi-automatic exploitation of imagery data; and semi-automated target recognition and tracking.

(U) **Program Change Summary:** (*In Millions*)	**FY1999**	**FY 2000**	**FY 2001**
Previous President's Budget	209.971	232.319	211.893
Current Budget	204.682	232.319	189.002

(U) **Change Summary Explanation:**

FY 1999 Decrease due to SBIR and Omnibus reprogramming 1415 reductions, and minor repricing.

FY 2001 Decrease reflects reduction in scope of the Organic Ground Moving Target Indication and rephasing of the Low Cost Cruise Missile Defense efforts. In addition, the SAR ECCM program completion was accelerated to FY 2000 vice FY 2001 as previously planned.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-01				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Guidance Technology SGT-01	32.878	21.466	22.340	22.633	32.964	33.764	36.564	Continuing	Continuing

(U) **Mission Description:**

(U) Fire-and-forget standoff weapons need precise targeting information if critical fixed and mobile targets are to be eliminated effectively with minimal collateral damage and minimum cost-per-kill. This requires that: (1) military surveillance and targeting systems geolocate targets accurately in the same coordinate system in which the weapon system navigates; (2) the surveillance, targeting and weapon systems have precision navigation and guidance systems on-board; and (3) navigation and target location systems robustly operate day/night and in adverse weather. In addition, future systems designed to accomplish precision strike missions must be significantly more affordable. The achievement of these characteristics in an integrated system is the goal of this program. The Global Positioning System (GPS) Guidance Package (GGP) technologies funded in this project are applicable for both new or retrofit guidance/navigation packages for a variety of airborne platforms, ground vehicles, surface-to-surface standoff weapons and air-to-surface weapons. Additional thrusts are also included in this project to increase the ability of GPS users to operate effectively in presence of enemy jamming; to increase the versatility of navigation systems applications by developing micro-electromechanical sensor inertial navigation system technologies; and to apply the geolocation technologies/techniques to precision threat geolocation (Advanced Tactical Targeting Technology Program).

(U) GGP tightly integrates a miniature GPS receiver and an all solid state, low cost, navigation-grade, interferometric fiber optic gyroscope (IFOG) based miniature inertial measurement unit (MIMU) with an advanced navigation computer into a low cost ($15,000), precision navigation system. GGP Phase I addressed the technology issues involved in: (1) miniaturizing navigation grade inertial measurement units (IMUs) into a compact, manufacturable configuration; and (2) developing a multi-channel-on-chip, high dynamics GPS receiver. A Memorandum of Agreement (MOA) has been signed and implemented to demonstrate a Phase 1 unit on an Army Fire Support Team Vehicle (FIST-V). Successful demonstrations were conducted at Redstone Arsenal in June 1995 using a M981 FIST-V. Successful demonstrations also were conducted on an F/A-18. These tests assessed the performance of tightly coupled systems in high dynamics and validated Phase 1 design scenarios. GGP Phase 2 requirements place more stressing demands on performance of MIMU components and call for further reductions in size, power and weight. The Phase 2 was structured and continues as a competitive program with two prime contractors. GGP applications include the Army Tactical Missile System and the Multiple Launch Rocket System.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-01

(U) The GGP program also will increase the ability of GPS users to operate effectively in the presence of enemy jamming or countermeasures (Global Positioning Experiments – GPX). It will demonstrate feasibility of airborne pseudolite (APL) concepts, which would sustain the availability of GPS signals to users in the presence of enemy jamming. The considerably increased transmit power of the APL fights off the effects of jamming on DoD receivers. APLs can be rapidly deployed on unmanned aerial vehicles (or other airborne platforms) and provide theater-wide coverage for individual soldiers, combat platforms and precision GPS-guided shoot-to-coordinate weapons. The project assesses two key challenges. First, it will demonstrate non-Keplerian orbit predictions of the APL and show that only software modifications are needed for GPS user receivers. Second, the APL must also accurately navigate using GPS satellites in the presence of jamming. Accordingly, this project provides for the design, development and demonstration of a low cost, all digitally controlled GPS receiver with a space time adaptive beamforming anti-jam antenna. A digital adaptive beamformer with advanced algorithms is capable of supporting greater than 45 dB nulls against up to six different jammers.

(U) The Micro-Electromechanical Sensor Inertial Navigation System (MEMS INS) program will improve the silicon based, inertial sensors (gyros and accelerometers) developed in the MEMS technology program and integrate them with navigation software into a low power, small, light weight, low cost, tactical grade (1.0 degree per hour to 10 degrees per hour drift rate) INS. In addition to handheld applications, the MEMS INS will be generic for insertion/embedding into other military systems. MEMS INS Phase 1 will perform the following: (1) design and develop higher performance appropriate MEMS inertial gyroscope and accelerometer sensors, (2) select and refine foundries/foundry processes, (3) design the mechanical subsystem, and (4) select/refine the navigation software and perform INS simulations of the modeled sensors. Phase 2 will develop the MEMS inertial sensors brassboard, integrate them into a MEMS INS and demonstrate the brassboard in the field.

(U) The Advanced Tactical Targeting Technology (AT3) program will demonstrate a passive tactical targeting system for the lethal suppression of enemy air defenses (SEAD). Today's threat radar targeting systems employed for SEAD fail to provide the rapid and accurate emitter geolocation needed to replace dedicated anti-radiation missiles (ARM) with generic, shoot-to-coordinate, smart weapons (e.g., JDAM or JSOW). The targeting system must negate emitter shutdown tactics now employed to defeat ARM guidance and enable simplified ordnance inventories. Generation and distribution of near real-time (e.g., seconds) comprehensive, and highly precise location of threat radars to all theater combatant aircraft is required without deploying any extra, SEAD dedicated, emitter collecting platforms. AT3 will accomplish this by widely deploying emitter collection packages hosted on existing airborne platforms, including combatant aircraft. AT3 will integrate in real-time the distributed multi-platform emitter collections using existing or planned tactical radios with advanced network management and signal processing. Additionally, to achieve the necessary wide deployment, AT3 self-contained collection packages must impose negligible burden on their airborne hosts and be available at affordable prices. Enabling technologies now in development at DARPA will be used, including highly agile digital receivers packaged in multichip modules (MCMs), highly precise tactical clocks, tightly coupled integrated GPS/INS packages and advanced highly

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-01

dynamic data fusion network management capabilities. Critical system advancements are (1) generating the commonly registered, theater-wide absolute doppler corrections to collected data and (2) managing the extraordinarily dynamic real-time data network including individual user kinematics and a changing aggregate participating user population.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- GPS Guidance Package (GGP). ($ 12.975 Million)
  - Maintained a second source for the GGP, thereby continuing as a competitive program.
  - Performed final integration and testing of GGP units
  - Proceeded with adaptive signal processing/beamformer to null jammers
  - Evaluated feasibility of airborne GPS pseudolites

- Micro-Electromechanical Sensor Inertial Navigation System. (MEMS INS). ($ 8.233 Million)
  - Iterated MEMS foundry inertial sensor fabrication and initiated preliminary sensor testing.

- Advanced Tactical Targeting (AT3). ($ 11.670 Million)
  - Completed AT3 preliminary design and system simulation

(U) **FY 2000 Plans:**

- GPS Guidance Package (GGP). ($ 4.000 Million)
  - Complete evaluation of the feasibility of pseudolites; continued and completed adaptive signal processing and digital beamformer.

- Micro-Electromechanical Sensor Inertial Navigation System (MEMS INS). ($ 8.800 Million)
  - Begin MEMS INS integration with navigation software to demonstrate INS operation.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-01

- Advanced Tactical Targeting. ($ 8.666 Million)
  - Complete Advanced Tactical Targeting critical design and begin fabrication.

(U) **FY 2001 Plans:**

- GPX. ($ 4.000 Million)
  - Complete refinement and evaluation of elements of the pseudolite network.
  - Conduct integrated demonstration.

- MEMS INS. ($ 6.000 Million)
  - Complete demonstration of MEMS INS operation.

- Advanced Tactical Targeting. ($ 12.340 Million)
  - Complete fabrication and ground tests.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-01

(U) **Schedule Profile:**

Plan	Milestones
Sep 99	Complete preliminary design of the AT3 demonstration system.
Oct 99	Complete signal processor for digital adaptive beamformer.
Oct 99	Deliver brassboard Micro-Electromechanical Sensor gyros.
Dec 99	Begin Phase 2 of the Micro-Electromechanical Sensor (MEMS) Inertial Navigation System (INS).
Dec 99	Complete critical design reviews and begin fabrication of adaptive digital beamforming GPS antenna array.
Dec 99	Conduct airborne pseudolite feasibility flight tests with user GPS receivers.
Mar 00	Complete AT3 critical component demonstrations and begin brassboard fabrication.
Jun 00	Complete laboratory test of digital adaptive beamformer.
Aug 00	Deliver GPS Guidance Package (GGP) units to the Government.
Oct 00	Deliver GGP units to the Government (second source).
Dec 00	Complete proof-of-concept testing of the digital adaptive beamformer and antenna array.
Sep 01	Complete AT3 ground tests.
Sep 01	Complete demonstration of MEMS INS operations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-02				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Aerospace Surveillance Technology SGT-02	65.465	77.712	67.438	89.798	100.232	84.500	109.300	Continuing	Continuing

(U) **Mission Description:**

(U) This project funds space and airborne sensor efforts that will improve the accuracy and timeliness of our surveillance and targeting systems for improved battlefield awareness. Timely surveillance of enemy territory under all weather conditions is critical to providing our forces with the tactical information needed to succeed in future wars. This operational surveillance capability must continue to perform during enemy efforts to deny and deceive the sensor systems, and operate, at times, in a covert manner. This project will exploit recent advances in multispectral target phenomenology, signal processing, large constellation satellite architectures, low-power high-performance computing, and low-cost micro-electronics to develop advanced surveillance systems. Surveillance is not an end to itself but rather an enabler for force protection and precision strike. Therefore a key component of this program is the development of a comprehensive sensor-to-shooter architecture.

(U) The Millimeter Wave Targeting & Imaging System (MMWTIS) program will develop and demonstrate the targeting and imaging technologies to enable a low-cost, all weather, day/night precision targeting approach against moving or stationary targets at millimeter wave (W band) frequencies. The technologies investigated will include active and passive techniques to achieve high resolution targeting (low circular error probability (CEP)) and imaging (1-3 m). An objective system could be used for weapons targeting, high-resolution imagery, and battle damage assessment. This program will pursue advanced radar algorithms and sparse aperture concepts, and intelligent incorporation of miniaturized monolithic integrated circuit (MMIC), advanced W band power amplifier technology, radio frequency photonics technology and low power high performance computing.

(U) The DARPA Digital Radio Frequency Tags program will develop the technology to allow radars (Moving Target Indication (MTI) and Synthetic Aperture Radar (SAR)) to receive data from ground devices. This program will develop a small, lightweight and affordable RF tag for data exfiltration from unattended ground sensors and communication with vehicles and personnel throughout the battlespace. This is particularly useful for the identification and location of coalition units. Additionally, the Digital RF Tag architecture can be exploited for other missions, with the net effect of substantially enhancing US situational awareness advantages.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-02

(U) The Adaptive Spectral Reconnaissance Program (ASRP) will develop the technologies for real-time detection of tactical targets employing concealment, camouflage, and deception using hyperspectral sensor data covering the visible through long wave infrared to cue high resolution target imagery. The program will develop algorithms, models, and phenomenology and advanced long wave infrared sensor technology, and validate these elements on an airborne testbed. The testbed will serve as a platform to validate the overall technical concept to conduct demonstrations of a real-time tactical directed area search capability. ASRP will employ visible and near infrared (VNIR)/short wave infrared (SWIR)/long wave infrared (LWIR) spectrometers, an on board, real-time data processor with multiple algorithms, and high resolution day/night imagers to provide cued high-resolution, geo-located imagery products to the analyst in support of the counter-camouflage, concealment and deception (CCC&D) mission. The developed system will be demonstrated on the ASRP testbed and subsequently on a surrogate unmanned aerial vehicle (UAV) platform.

(U) The Discoverer II program is a DARPA, Air Force and National Reconnaissance Office (NRO) joint initiative to develop and demonstrate an affordable space-based radar (SBR) with Ground Moving Target Indication (GMTI) and Synthetic Aperture Radar (SAR) imaging capabilities that will revolutionize reconnaissance, surveillance and precision geolocation support to the tactical warfighter. Discoverer II is the direct descendant of the DARPA STARLITE initiative. In January 1998, the Defense Science Board (DSB) Task Force on Satellite Reconnaissance issued its report. The Task Force recommended that a modified STARLITE program be initiated, as a "Military Space Radar Surveillance Program," in an effort to achieve broad-area, all-weather, near-continuous radar access that could be integrated with military operations. Two central findings of the Task Force were that an on-orbit demonstration would likely be needed; and that a technical risk reduction program should be undertaken in advance of the demonstration to bring leading edge, higher risk technologies to bear to both meet warfighter needs at lower cost, and to enhance system maturity thereby facilitating a more direct and rapid transition to a follow-on operational system.

(U) Discoverer II is a staged technology demonstration program. In the first phase industry will conduct detailed trade studies necessary to define both an affordable objective space-based radar system for the 2008 timeframe and a demonstrator system for the 2004 timeframe that shows the ability to achieve the proposed objective capability. Concurrent with the performance of trade studies by Discoverer II system integration contractors, results of the Tactical Radar program will be exploited, and other risk reduction initiatives will be undertaken to ensure Discoverer II system development can be pursued with acceptable risk. Specifically, the technologies to be pursued include: 1) developing a low-cost, multi-mode GMTI/SAR space-qualified electronically scanned antenna, 2) developing low power Microelectromechanical Systems (MEMS) for scanning radar modules (10x reduced power requirement), and 3) sparse band processing for data compression allowing on-ground processing with .5Gbps links, and Automatic Target Recognition (ATR) quality (.5m) range profiling. The proposed satellite system will also use an interferometric synthetic aperture radar (IFSAR) capability to produce high-accuracy digital terrain elevation data (DTED) to support both battlefield visualization (BV) and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-02

precision guided munitions (PGM) targeting (3m or less geolocation accuracy theater wide). If industry trade studies, informed by the results of the Discoverer II risk reduction initiatives, show an affordable objective system is achievable, Phase II will be entered: the actual building and flying on-orbit of two GMTI/SAR technology demonstration satellites. That demonstration will validate the technical feasibility of: advanced C4ISR capability complementing/extending current UAV/Aircraft architecture providing deep-look, denied area, near continuous, diverse look angles over the battlefield to enable mobile target detection, tracking, and targeting; intelligence preparation of the battlefield; wide area search and precision engagement with direct downlink to the warfighter. A "go-ahead" decision to proceed with follow-on acquisition would be made after the completion of the Discoverer II demonstration program, sometime after FY 2004.

(U) The Novel Antennas Program is developing novel techniques to produce small, lightweight systems with low power requirements that are capable of locating specific emitters in a dense interference environment. The program will leverage major investments already made in photonics, antennas and space-time adaptive array processing with the latest advances in digital receivers, signal processors, and devices employing superconductivity. Both centralized and distributed sensor/array architectures are explored. Prior to FY 1999 the program funding was distributed amongst the component technology development programs. During FY1999, the distributed architecture was refined to include spectrum supremacy, the ability to deliver novel radio frequency (RF) capabilities to organic ground combat vehicles (e.g. Abrams tanks, HMMWVs).

(U) Underground Facilities (UGFs) are being increasingly employed to hide a variety of strategic functions, including command and control and weapons of mass destruction associated activities. The Counter-Underground Facilities program (CUGF) will develop technologies to characterize UGFs along the entire kill chain: identification of facility function, UGF pace of activity, pre-attack status of the facility, trans-attack activities, and post-attack status. Techniques will be developed to determine locations of critical umbilicals and systems (power, water, airflow vents), orientation and depth of structure, and pre-strike and post-strike changes in the substructure resulting from attack. Both remote and proximal technologies will be studied. Candidate technologies include, but are not limited to, vibrometry (close-in and standoff), low frequency electromagnetics, multi/hyperspectral imaging, seismic imaging, and micromechanical systems for close access tagging and sensing

(U) Non-Linear Radar Communications Mapper (NLRCM): High valued camouflaged targets usually have radio transceivers for command and control purposes. To avoid detection, an attempt is frequently made to operate these radios primarily in the receive mode and to minimize radio transmission. Exploiting nonlinearities in the radio receiver, it may be possible to design a radar to detect and locate these radios while they are in the receive mode or possibly while they are in a standby mode. It has been postulated that if a radio receives a high powered tone, due to nonlinearities in the receiver, it will reradiate an intermod of the received frequency and the frequency to which it is tuned. Alternatively, if two tones are received, the radio will transmit an intermod of the two received frequencies. The radar systems concept is to develop either an airborne or

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-02

satellite pulse Continuous Wave (CW) radar to detect, locate and map the locations of radio equipment based upon their nonlinear intermod behavior. This program will exploit legacy communications technology developed under the Novel Antennas program into various application domains.

(U) The Large Millimeter Wave Telescope (LMT) program will develop the largest (50 meter aperture) fully steerable millimeter wave radio telescope built to date. The design features a sophisticated laser metrology system to maintain precise alignment of the optics, and real time closed loop adaptive control actuator system to maintain a near-perfect parabolic surface at all pointing angles and under most environmental conditions.

(U) **Program Accomplishments and Plans:**

(U) **FY1999 Accomplishments:**

- Millimeter Wave Targeting & Imaging System (MMWTIS). ($ 2.017 Million)
  - Completed concept development studies.
- Radio Frequency (RF) Tags. ($ 7.770 Million)
  - Completed development and testing of ID-only RF Tags for use with Synthetic Aperture Radar (SAR) and Moving Target Indicator (MTI) airborne radar platforms.
  - Continued design of data encoding and extraction algorithms for tags. Conduct design trades for miniaturizing the tags.
  - Initiated digital tag development.
- Adaptive Spectral Reconnaissance. ($ 5.643 Million)
  - Initiated development of end-to-end spectral model to include real/synthetic imagery generation, atmospheric/path radiance components, and sensor models, platform dynamics and algorithm segments.
  - Conducted joint data collects in Southeastern US (Eglin AFB) and Southwestern US (National Training Center, Yuma Proving Grounds, and at Nellis AFB as part of JEFX 99 exercise).
  - Achieved airborne real-time cued target detection using VNIR/SWIR hyperspectral sensor.
  - Continued data analysis and creation of spectral target and background signature database.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-02

- Continued algorithm development, including implementation of fusion methodologies to reduce false alarms.
- Awarded contract for development of compact high sensitivity long wave infrared (LWIR) hyperspectral sensor with high resolution imager.

• Discoverer II. ($ 31.476 Million)
- Supported jointly funded effort to conduct design trades and analyses leading to the candidate objective system and demonstration system designs by awarding three system integration (SI) contracts in Feb 99. Core activities focused on cost/performance trades and completion of an Integrated Master Plan/Schedule. The initial Interim Evaluation Review was conducted in 4QFY99.
- Supported jointly funded risk reduction efforts in key risk areas to include antenna design and fabrication, advanced signal processing, and exploitation software. Completed Thinned Transmit/Receive (T/R) Module Electronically Scanned Array (ESA) design.
- Conducted mission utility analyses and concept of operations studies.

• Novel Antennas. ($ 12.559 Million)
- Pursued data collection, and demonstrated algorithm performance against emitters in a realistic interference environment (urban, desert and hilly deciduous forest). Urban and non-urban environments were explored. Distributed architectures were developed and assessed, supporting hardware developed and demonstrated, and algorithm performance was evaluated. The integrated system design was developed. An experiment was also conducted to determine the utility/synergy of close access, distributed collection capability into a distributed architecture. Networked sensors, which leverage software reprogrammable radio technology, were employed to assess the utility of distributed architectures.

• Counter-Underground Facilities. ($ 4.500 Million)
- Convene a signal hypothesis working group consisting of the nation's experts in a variety of disciplines critical to the counter underground facility problem including seismology, acoustics, low frequency electromagnetics, geology, and others. The working group will identify and model critical underground facility signatures, propagation phenomenology and backgrounds and identify critical unknowns and define experiments to resolve them.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-02

- Large Millimeter Wave Telescope (LMT). ($ 1.500 Million)
  - Completed preliminary critical system design.
  - Completed site characteristic measurements through seismic and wind monitoring.

(U) **FY 2000 Plans:**

- Radio Frequency (RF) Tags. ($ 7.051 Million)
  - Conduct a Preliminary Design Review (PDR) for a digital RF Tag, system level trade study, and technology insertion plan; continue development of data encoding and extraction algorithms.

- Adaptive Spectral Reconnaissance. ($ 4.000 Million)
  - Complete validation of end-to-end spectral model including real/synthetic imagery generation, atmospheric/path radiance components, sensor models, platform dynamics, and algorithm segments.
  - Continue algorithm development, including implementation of new algorithms and hybrid fusion techniques.
  - Complete spectral target and background signature database and release for distribution.
  - Continue sensor development and data collection and demonstration activities.

- Discoverer II. ($ 50.661 Million)
  - Support jointly funded effort to complete preliminary design of the demonstration system.
  - Continue ground moving target indication (GMTI) radar satellite design efforts for two or three system integration (SI) contractor teams.
  - Continue risk reduction activities in key areas, to include: antenna design and fabrication, advanced signal processing, and exploitation software.
  - Conduct mission utility analyses and concept of operations studies.
  - Support jointly funded effort to begin detailed design and long lead procurement for selected demonstration system (Phase II).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-02

- Novel Antennas. ($ 4.500 Million)
  - The Novel Antennas program will transition technology to a ground based military system for real-time urban, desert, mountain and littoral operations. Adjunct platforms will be pursued for technology transfer and system integration.

- Counter-Underground Facilities. ($ 11.500 Million)
  - Initiate robust analysis and experimentation of key observables and backgrounds.
  - Modeling efforts will be initiated in critical areas, such as seismic propagation, effluent spectroscopy, and other related areas.
  - Sensor system studies will be performed to explore the value of observables, exploit reliable signal correlations, estimate objective sensor system performance, and identify critical technology initiatives.
  - Technologies to be developed include passive seismic/electromagnetic sensing, active seismic imaging, spectroscopy for standard effluents, and remote techniques.

(U) **FY 2001 Plans:**

- Radio Frequency (RF) Tags. ($ 7.400 Million)
  - Complete Critical Design Review (CDR) for digital RF tag; conduct risk reduction tests.

- Discoverer II. ($ 40.409 Million)
  - Continue Phase II: System integration (SI) contractor(s) complete(s) detailed design of ground moving target indicator (GMTI) radar demonstrator system for the 2004 timeframe that will validate the feasibility of achieving the Discoverer II program objective. Conduct critical design review (CDR) for system detailed designs.
  - Initiate procurement of long-lead items for two GMTI/ synthetic aperture radar (SAR) demonstration satellites.
  - Continue on-going signal processing and target tracking algorithm development.
  - Continue software demonstrations.
  - Support jointly funded risk reduction efforts in key risk areas to include antenna design and fabrication, advanced signal processing and exploitation software.
  - Conduct mission utility analyses and concept of operations studies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	**R-1 ITEM NOMENCLATURE** Sensor and Guidance Technology PE 0603762E, Project SGT-02

- Counter-Underground Facilities. ($ 12.000 Million)
  - Continue robust modeling and experimentation.
  - Extensive field measurements will be taken to verify model performance and verify sensor deployment concepts.
  - Prototype development activities will begin on selected technologies.
  - Critical component technology development will begin.
  - Field measurements will be taken to verify model performance and verify sensor deployment concepts.

- Non-Linear Radar Communications Mapper. ($ 7.629 Million)
  - Perform assessments of nonlinear radar phenomenon to detect critical mobile targets under camouflage and underground facilities via non-linear scattering from their communications equipment and initiate system concept development.

(U) **Other Program Funding Summary Cost:** *(In Millions)*

Adaptive Spectral Reconnaissance:

Source	FY 1999	FY 2000	FY 2001
DARO			
Army	3.2	4.0	2.0*

* under review

Discoverer II:

Source	FY 1999	FY 2000	FY 2001
NRO	29.9	29.2	34.7
Air Force	15.5	28.7	54.6

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-02

(U) **Schedule Profile:**

Plan	Milestones
Radio Frequency (RF) Tags:	
Mar 00	Conduct Preliminary Design Review (PDR) for digital Radio Frequency (RF) Tag.
Sep 00	Conduct Critical Design Review (CDR) for digital RF Tag.
Oct 01	Brassboard digital tag.
Oct 02	Prototype digital tag.
Adaptive Spectral Reconnaissance:	
Oct 99	Conduct Preliminary Design Review (PDR) for LWIR sensor.
Jan 00	Conduct Critical Design Review (CDR) for LWIR sensor.
Jan 01	Deliver LWIR hypyerspectral sensor with high-resolution thermal imager.
Discoverer II:	
Sep 99	Interim Evaluation Review (IER) #1.
Dec 99	Electronically Scanned Array (ESA) Transmit/Receive (T/R) Thread Test.
Dec 99	Frequency Allocation/Filing.
Dec 99	Terrain Mapping Error Model/Budget.
Feb 00	Polyphase Channelizer Demo.
Mar 00	Interim Evaluation Review (IER) #2.
Mar 00	Award Continuation Option to Selected SI Contractor(s).
Jun 00	ESA Brassboard Demo.
Jun 00	Select Final Design(s).
Aug 00	Award Phase II SI Contract for detailed design of the demonstration system.
Jul 01	SI Contractor(s) Critical Design Review (CDR).
Jun 02	Common Data Link (CDL) Space-Qualification Mod.
Dec 02	Begin Spacecraft Integration.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-02

Sep 03 Launch Satellite #1.
Dec 03 Launch Satellite #2.
Sep 04 Joint Program Termination.

Novel Antennas:
Sep 99 Demo system completed.
Apr 00 Final data collection.
Jul 00 Wideband link demonstration.
Sep 00 Transition.

Counter-Underground Facilities:
Oct 99 Initiate model development and validation for seismic, acoustic, and EM.
Oct 00 Model verification complete. Sensor system developments initiated.

Non-Linear Radar Communications Mapper Program:
Aug 01 Complete initial assessment of non-linear scattering of communications equipment.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)									DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development					R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-03				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Air Defense Initiative SGT-03	24.430	42.350	23.471	19.960	30.000	38.000	38.200	Continuing	Continuing

(U) **Mission Description:**

(U) This project encompasses several advanced technologies related to the development of techniques to counter advanced battlefield threats. These programs include the Synthetic Aperture Radar Electronic Counter-Countermeasures (SAR ECCM) program, the Low-Cost Cruise Missile Defense (LCCMD) program, the Air Directed Surface-to-Air Missile (ADSAM) program, the Adjunct Airborne Early Warning (AEW) program, and the Microelectromechanical (MEM) antenna (MEM-tenna) program.

(U) The SAR ECCM program will develop techniques to make U.S. Synthetic Aperture Radar (SAR) systems less vulnerable to intentional enemy jamming or deception. SAR systems have become one of the most widely used broad area surveillance systems. They are critically important to the development of battlespace awareness and their jamming and/or deception could seriously degrade U.S. warfighting capability. The SAR ECCM program will determine the military impact of various SAR jamming techniques and develop countermeasures against the highest priority threats.

(U) The LCCMD program will employ existing and emerging technologies to develop an affordable missile interceptor. This interceptor is directed at defeating a threat consisting of unsophisticated air vehicles attempting to overwhelm US defenses by attacking in large numbers or by attacking over wide geographic areas. The air vehicle threat includes cruise missiles, unmanned aerial vehicles, helicopters, and low-flying aircraft that are capable of delivering conventional, chemical or biological weapons and conducting jamming or surveillance missions. The LCCMD program will downselect from a field of six promising low cost seeker concepts based on the results of analyses, laboratory tests, ground tests, and captive flight tests. The most promising seeker will be integrated with a Miniature Air Launched Decoy (MALD), modified to serve as an interceptor, for live fire testing and transition to the military Services.

(U) ADSAM: The purpose of this joint DARPA/AMCOM/USMC/AMRAAM program office project is to rapidly demonstrate enabling technologies and operational concepts to support the destruction of low flying, stressing targets, such as cruise missiles. This project demonstrates the critical technologies required to destroy such targets beyond the line-of-sight and at the full intercept range of surface-to-air missile systems. This live fire demonstration program uses an elevated platform to provide target cueing and updates to Advanced Medium Range Air to Air Missiles (AMRAAM). These missiles are ground launched from modified High Mobility Multi-Purpose Wheeled Vehicles (HMMWV) developed by

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-03

DARPA and AMCOM, known as the HUMRAAM. This demonstration program also supports the Marine's ongoing HUMRAAM program, called the Complimentary Low Altitude Weapons System (CLAWs), by allowing them to quickly progress from concept development through demonstration/validation in less than 1 year. Early successes with the HUMRAAM have led the Marines to include its further development and acquisition in their FY 2000 POM.

(U) The Adjunct Airborne Early Warning (AEW) program will demonstrate the feasibility of ultra-lightweight, multi-aperture, multi-function radar technology in UAVs. A UAV outfitted with this technology could provide lower cost (factor of 20), continuous air and ground surveillance of low intensity areas such as no-fly zones and peace keeping areas. Such capability could supplement traditional AWACS and E2-C, and reduce the requirement to forward base large numbers of manned aircraft for these purposes. This program will also support the demonstration of the ability to get an order of magnitude more ground coverage in a GMTI mode through very wide-band off-board communications and large numbers of phase centers. The key technologies to be used are high efficiency solid state transmitters, composite lightweight integrated antennas, and advanced mode control/interleaving algorithms. Concepts will be explored which use common components to perform both the AEW mission (at the reduced ranges appropriate to this concept), and air-to-ground modes. The latter will support networking concepts, which reduce cost and enable precision moving surface target engagement.

(U) The MEM-tenna program will develop an ultra-low cost; lightweight phased array antenna based on MEMS phase shifters and Digital Mirror Device (DMD) technologies. MEMS technology can produce phase shifters for phased array antennas that are a small fraction of the power consumption of conventional PIN-diode or GaAs FET phase shifters, while also having low insertion losses. Hard-wired beam steering control and RF manifolds are replaced by optical and RF space-fed configurations. Using these technologies, very large-scale electronically scanned arrays (ESAs) can be developed for airborne, ship- and space based applications. Phase shifter designs incorporating MEMS technology are being developed, and these will be incorporated into a prototype ESA having 10,000 antenna elements, operating at X-band.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-03

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- SAR ECCM. ($ 7.309 Million)
  - Selected ECCM techniques were implemented for mitigating low-level ECCM threats in the analog (front end) and image domain portions of the radar. Data was collected to validate the calculated impacts and support further technique development. A laboratory demonstration of the selected ECCM techniques supported several high-level experiments using test and operational platforms.

- LCCMD. ($ 14.377 Million)
  - Three low-cost seekers made substantial technical progress: the noise radar seeker, the Microelectromechanical Electronically Steered Array (MEMS ESA) seeker, and the laser seeker. The noise radar seeker team successfully completed a Critical Design Review and has begun fabrication and integration of seeker hardware to be used for captive flight-testing. The MEMS ESA seeker team fabricated and tested a MEMS phase shifter. The phase shifter, the key technology required to fabricate the MEMS seeker antenna, exceeded performance requirements. The laser seeker team fabricated and demonstrated a brassboard seeker. The seeker exceeded range accuracy and came very close to meeting angle accuracy requirements. A noisy circuit has been identified and is being redesigned to improve angle accuracy.

- ADSAM. ($ 2.745 Million)
  - Modifications to the HUMRAAM developmental system were completed. Analysis of the flight test results, comparisons to predictions and model modifications were completed. Technical lessons learned, including software and hardware was transferred to the air defense community for future ADSAM live fires with other missiles (Standard Missile, Patriot, etc).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-03

(U) **FY 2000 Plans:**

- SAR ECCM. ($ 9.050 Million)
  - The design and implementation of the selected ECCM techniques will be completed and demonstrated in a series of off-line final technique demonstrations. These demonstrated techniques will begin transition into selected operational platforms to mitigate the rising proliferation of inexpensive modern threat systems. The SAR ECCM program will be integrated into the annual Expeditionary Force Exercise (EFX).
- LCCMD. ($ 21.000 Million)
  - The noise radar seeker team will complete fabrication, complete seeker ground testing, and initiate non-real time captive flight testing using an A-3 aircraft and tactically representative airborne targets. The MEMS ESA seeker team will complete a Systems Requirements Review, complete a Preliminary Design Review, and fabricate and test a tactically form-factored transmit/receive antenna. The laser seeker team will complete a Systems Requirements Review, complete a Preliminary Design Review, and field-test a ground based laser system against tactically representative airborne targets.
- Adjunct AEW. ($ 3.500 Million)
  - Begin the development and fabrication of a subarray portion of a prototype composite, lightweight, integrated phased array antenna to demonstrate that the desired antenna concepts can be implemented while also achieving the design goals of low weight and cost. Mode control/interleaving algorithms will be developed. Also, the preliminary design for a means of carrying a complete radar system on a UAV, such as the Global Hawk, will commence.
- MEM-tenna. ($ 8.800 Million)
  - Modify existing designs of MEMS X-band phase shifters and initiate prototype manufacturing. The design of a prototype ESA that will incorporate the completed MEMS phase shifters will also begin.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-03

(U) **FY 2001 Plans:**

- LCCMD. ($ 13.571 Million)
  - The noise radar seeker team will complete non-real time captive flight testing and flight test data analysis. The flight test data will subsequently be used to demonstrate in the laboratory real time processing using a noise seeker processor developed by the program. Both the MEMS ESA and laser seeker teams will complete Critical Design Reviews for a form-factored seeker. The government will select a single seeker and initiate the fabrication of a form-factored seeker for live fire testing based on the results of analyses and tests conducted during FY 2000.

- Adjunct AEW. ($ 3.500 Million)
  - The completed subarray will be laboratory tested.

- MEM-tenna. ($ 6.400 Million)
  - Manufacture of a full-scale antenna using MEMS phase shifters will begin. A transmitter and beam controlling processor will be integrated with the array. Calibration techniques with specific and general applicability will be developed. Planning for the final integration and test planning will start.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-03

(U) **Schedule Profile:**

Plan	Milestones
LCCMD:	
May 00	Start Laser Seeker Ground Testing
Jun 00	Start Noise Seeker Ground Testing
Sep 00	Start Noise Seeker Flight Testing
Sep 00	Start MEMS ESA Antenna Testing
Aug 01	Start Selected Seeker Captive Flight Testing
SAR ECCM:	
Aug 00	Field ECCM Demonstration
Adjunct AEW:	
Dec 99	Begin MEMS filter development
Jul 01	Complete basic subarray fabrication and lab testing
MEM-tenna:	
Jan 00	Begin design of 10,000 element MEM-tenna demonstration system
Dec 01	Complete production of 11,000 MEMS phase shifters

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04				
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Sensors and Exploitation Systems SGT-04	81.909	90.791	75.753	93.695	88.286	92.832	92.832	Continuing	Continuing

(U) **Mission Description:**

(U) The development efforts described herein embody key sensor demonstrations and the exploitation of sensor products. These efforts, in conjunction with those described in Projects CCC-02 and SGT-02, seek to develop the systems needed to provide the warrior with situational awareness and precision target identification and attack capability. The strategic goals of this project are to: develop key sensor technologies required to support battlefield dominance, including sensors which can counter Camouflage, Concealment and Deception (CC&D); provide near-real-time, semi-automatic exploitation of wide-area moderate (and high) resolution imagery; and provide semi-automated recognition, robust, precise and reliable identification, and precision fire control tracking of high value units and critical moving targets. These goals are being addressed by the Counter CC&D Program; the Semi-Automated Imagery Intelligence (IMINT) Processing (SAIP) Advanced Concept Technology Demonstration (ACTD); Moving and Stationary Target Acquisition and Recognition (MSTAR) program; Moving Target Exploitation (MTE) Automatic Target Recognition (ATR) applications programs; Eyeball, a multispectral electro-optical (E-O)/infrared (IR)/radar identification concept; Airborne Video Surveillance (AVS) program; Affordable Moving Surface Target Engagement (AMSTE) program; Real-Time Synthetic Aperture Radar Battle Damage Assessment (SAR BDA) program, and the Organic GMTI Radar (OGR) program.

(U) The goal of the Counter CC&D Program is to significantly enhance the military's capability to detect obscured targets hidden under foliage and camouflage. Specific goals include validation of Foliage Penetration (FOPEN) target detection capability (detect 80% of the targets with 0.1 FA/sq.km) using a FOPEN Synthetic Aperture Radar (SAR). The FOPEN SAR will be developed for demonstration on a manned platform (Army RC-12) providing inputs via narrowband tactical data links for ground image exploitation. A Ground Control and Display Subsystem (GCDS) is being developed to provide real time, remote operation of the FOPEN SAR, Automatic Target Detection and Cueing (ATD/C), and a Common Imagery Ground/Surface System (CIGSS)-compliant exploitation interface. The image exploitation processing of SAIP will be extended via the Multisensor Exploitation Testbed (MSET) for FOPEN as well as Multi/Hyper Spectral Image (MSI/HSI) sensor input, geolocation and multi-sensor fusion processing of images, and detection of time critical targets. The program will ultimately combine FOPEN SAR on the Global Hawk High Altitude Endurance Unmanned Aerial Vehicle (HAE UAV) with other airborne sensors (e.g., the Senior Year Electro-Optical Reconnaissance System (SYERS P31) on the U-2) and modes (GMTI/passive detection), and develop integrated exploitation technologies for insertion into the CIGSS. Analyses will also be carried out to evaluate the capability for FOPEN Ground Moving Target Identification (GMTI) radar and Electronic

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

Support Measures (ESM) under the FOPEN Radar and ESM Sensor Integration for Target Engagement (FORESITE) Study Program for increasing the effectiveness of Counter CC&D on future system designs.

(U) The Semi-Automated IMINT Processing (SAIP) ACTD will develop, test and transition to the operational user, automated algorithms and semi-automated tools that enhance the warfighter's capability to: process SAR, and later EO imagery; conduct wide-area search for Ground Order of Battle and Missile Order of Battle targets; perform rapid site modeling and site monitoring; and produce target reports in near real-time (< five minutes). Goals for the baseline system are automatic target cueing and classification for a limited set of vehicles (10 targets); object level change detection; force recognition to the company level; and interactive target recognition and terrain delimitation. Goals for an enhanced system are increasing the automatic target cueing and classification to 20 targets; site modeling and monitoring with EO and SAR; and addition of SIGINT cueing. An enhanced-fielded system will further increase automatic target recognition to 30 targets.

(U) The goal of the Moving and Stationary Target Acquisition and Recognition (MSTAR) program is to achieve a major advance in Automatic Target Recognition (ATR) performance based on the use of SAR imagery. This is accomplished through fundamental and innovative technology and algorithmic developments, large-scale data collections, and detailed system evaluations. The approach to detecting stationary targets utilizes traditional ATR techniques to first determine suitable target candidates for those image regions of interest (ROIs) that have been selected based on their likelihood of target content. A model-driven subsystem then refines these target candidates by using a SAR signature prediction module to determine the true target ID of the target within the ROI. Other program goals include: significant advances in tools including ATR tools and capabilities to efficiently perform interactive image exploitation; development of rapid target model construction technologies; collection and dissemination of high-quality databases of SAR signatures, development of resource management systems for surveillance and exploitation; and development and demonstration of compression-based techniques to reduce communication bandwidths for SAR-based wide area search platforms to SATCOM-supportable bandwidths. The latter uses statistical representation of the background to perform aggressive compression and wavelet-based approaches to compress detected targets to maintain signature fidelity and is referred to as "intelligent bandwidth compression" (IBC).

(U) The Moving Target Exploitation (MTE) program's objective is to provide significant improvements to the exploitation of ground Moving Target Indicator (MTI) radar data by providing previously unavailable capabilities to automatically detect, track, and classify high-valued ground-moving targets and maneuvering formations using all-weather airborne surveillance radar data. Four techniques are being investigated and evaluated: the automatic tracking of ground moving vehicles; the automatic analysis of moving vehicle motion patterns and behavior patterns to identify purposeful military movement; the discrimination of desired targets from other moving vehicles using high range resolution (HRR) MTI range profiling and 1-D automatic target recognition; and the imaging of specific moving targets via enhanced moving target imaging (MTIm)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

processing. Specific applications are targeted for MTI sensors on board the Joint Surveillance, Target, and Attack Radar System (Joint STARS), U-2, and Global Hawk platforms. In addition, system-level approaches for the application of complex-data techniques will be investigated, developed and integrated, including scatterer-specific imaging (SSI) for enhanced ATR with reduced false-alarm rates and systematic applications of coherent change-detection (CoCD).

(U) The goal of the Airborne Video Surveillance (AVS) program is to build and evaluate Airborne Video Surveillance technology to increase the tactical usefulness of video (visible and infrared) data from manned reconnaissance aircraft and Unmanned Air Vehicles (UAVs). The following semiautomatic capabilities will be developed: Precision Video Registration (PVR): the real-time geolocation (2-10 meter accuracy) of moving and stopped targets in airborne video imagery using precision geo-referenced orthomosaics as reference imagery; Activity Monitoring (AM): the reliable detection of specific events (soldier incursion, removal of vehicles from cantonment areas, etc.) of points, operations areas and lines of communication (LOC); and Multiple Target Surveillance (MTS): the simultaneous tracking of multiple ground vehicles (up to 12 targets)in the sensor platform area of regard but outside a single sensor field of view.

(U) The goal of the Affordable Moving Surface Target Engagement (AMSTE) program is to develop and demonstrate the technologies required to perform affordable, all-weather, precision negation of moving surface targets (both land and sea based). The use of netted ground moving target indication (GMTI) sensors will be explored using existing and planned sensors to produce a precision ground moving target fire control solution. Integrated weapons system architectures will be evaluated and demonstrated which include netted air-to-ground GMTI sensors; fighter-based weapons, long range precision weapons, and gun launched weapons. In-flight midcourse and terminal guidance to weapons will also be explored to drive weapon system CEP's an order of magnitude below current systems against moving targets. The precise cueing from the netted GMTI sensors will allow for lower cost weapons by reducing the complexity of, or eliminating entirely, the weapon's terminal guidance seekers. Additionally, collateral damage will be minimized by virtue of the very precise targeting and midcourse/terminal phase flight updates. The AMSTE program will begin with a thorough characterization of GMTI sensor fire control feasibility including advanced multi-sensor tracking and association algorithms, Space Time Adaptive Processing (STAP) to reduce sensor minimum detectable velocity and multi-sensor data collection/analysis to verify fire control accuracy predictions. Communications and weapons system studies will also be conducted to minimize weapon cost.

(U) The Eyeball program, a multispectral E-O/IR/Radar identification concept, is founded on the fact that prospective radar assets will be able to detect, locate and provide some forms of target classification. Because of radar and signature limitations, the identification provided may be insufficient for actual targeting and allocation of attack assets. The Eyeball program will investigate novel concepts for standoff identification of

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

moving targets by electro-optical sensors working in conjunction with air- and space-born radar Ground Moving Target Indicator (GMTI) and Synthetic Aperture Radar (SAR) sensors. Microdoppler target signatures of ground vehicles could be exploitable and offer a new dimension for reliable target identification. Once identified, the targets can be tracked using the same radar-based assets. This program will test sensors combining various degrees of spatial resolution with polarimetric and spectral sensitivity to identify targets at standoff ranges. The program will also develop concepts for providing this capability on fielded and fieldable platforms.

(U) The goal of the Real-Time Synthetic Aperture Radar Battle Damage Assessment (R/T SAR BDA) program is to develop and evaluate technology to permit all-weather, in-theater assessment of the effects of precision weapons on soft mobile threat targets such as surface-to-air missile launchers, theater surface-to-surface missile launchers, and multiple rocket launchers. R/T SAR BDA will exploit organic and theater synthetic aperture radar sensors to assess effectiveness of munitions delivery and provide feedback to attack systems in-mission, with a goal of providing weapon effectiveness metric feedback to the operator within 10 minutes of engagement. R/T SAR BDA will focus on identifying and assessing weapons effects from precision guided munitions, submunitions, sensor-fuzed weapons, and weapons that typically provide less energetic effect on the target and are, therefore, more difficult to assess by traditional BDA techniques.

(U) The goal of the Organic GMTI Radar (OGR) program is to develop the technologies to enable a low cost capability for the detection and tracking of moving vehicles and personnel, through foliage, using "organic" assets for Army or Marine units. The goal is to detect vehicles at ranges of 10 – 20 km and personnel at ranges out to 10 km with low false alarm rates. The concept is based on the use of separate transmitters and receivers, each of which is designed for low cost and portability. False alarm reduction and target tracking will be achieved through the creation of multiple narrow azimuth receive beams using high-speed digital beam forming computers. To ensure adequate foliage penetration, the system will be designed to operate in the VHF-UHF frequency regime. The ultra-miniature receivers located at each receive antenna array will be connected to the central signal processor via fiber optic links for ease of setup and to provide for the reduced cost and weight of the overall system. The use of commercial HDTV broadcasts, as a potential source of illumination energy will also be evaluated in this effort.

(U) The goal of Surface Target Recognition and Identification (STRIDE) is to achieve confirmed identification target recognition of surface targets through new modeling technology. STRIDE will investigate novel sensing modalities including the use of ultra-high bandwidth, ultra-high resolution, full polarimetric, and multi-look with angle diversity sensing, in order to achieve massive improvements in recognition confidence.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

(U) **<u>Program Accomplishments and Plans:</u>**

(U) **<u>FY 1999 Accomplishments:</u>**

- Counter CC&D. ($ 32.338 Million)
  - The Counter CC&D Program completed development of the FOPEN SAR Manned Airborne Demonstrator hardware. A critical design review of the integrated Multisensor Exploitation Testbed (MSET) has been conducted in preparation for FY 2000 development tests of FOPEN and SYERS MSI exploitation and Counter CC&D Tests. Advanced FOPEN and MSI/HSI ATD/C algorithms have been extended to provide increased georegistration accuracy and potential for reduction of false alarm density through sensor fusion. Analysis of FORESITE system concepts combined with a FOPEN GMTI/ESM data collection to verify concepts and verify attenuation models at shallow angles has been accomplished.

- SAIP ACTD. ($ 13.488 Million)
  - The Semi-Automated IMINT Processing (SAIP) operational assessment was completed and the final transition configuration of the system stood up. Demonstration of all software upgrades was conducted. Interim operational capabilities were transitioned for integration into the US Air Force Flight Test Facility and to the Army ETRAC system.

- MSTAR. ($ 20.083 Million)
  - Using new data collections, including Global Hawk data acquired through the sensor emulation Platform (SEP) and other SAR imagery sources, the 20 target MSTAR system with extended operating conditions (EOCs) was evaluated. Scalability of the MSTAR system was demonstrated by extension to a 25-target capability. MSTAR based technologies began integration with SAIP and STARLOS technology, and transition to a real time demonstration system also began. Multiple modes of radar processing (high range resolution, Inverse SAR, phase history) were investigated to improve performance on stationary targets. A series of MSTAR Enhancement Projects (MEP), designed to explore the use of higher resolution, the addition of new signature features, extraction of targets from raw radar returns, and increased computational parallelization were also initiated. Development and evaluation of rapid target insertion and interactive exploitation systems continued, with key milestones occurring in FY 2000.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

- Moving Target Exploitation (MTE). ($ 16.000 Million)
  - The MTE Program demonstrated the effectiveness of MTE on-board JSTARS T3 Testbed against a complex set of military vehicles during the Air Force Expeditionary Force Exercise. The first build of the MTE-CGS ground station was completed and demonstrated using synthetic sensor emulation platform (SEP) data. A proof-of-concept study was conducted to assess the technology to support affordable, precise, moving surface target engagement. Weapon system trade studies were conducted to investigate communication requirements, weapon system CEPs for a variety of weapon systems, weapon cost reduction, battle management requirements, and low cost sensor to weapon link designs.

(U) **FY 2000 Plans:**

- SAIP ACTD. ($ 4.532 Million)
  - Operational support to the Army and Air Force SAIP residual operational capability will be provided through the second quarter of FY 2000.
- MSTAR. ($ 15.521 Million)
  - Using newly collected SAR data, the MSTAR Enhancements Program will demonstrate major improvements in ATR performance through the use of ultra-high resolution SAR. An integration and transition capability will be established in the Real Time ATR Laboratory (R/T ATR Lab) for the purpose of developing MSTAR based "modules" that can be used to upgrade operational ATR systems such as SAIP. The ability to operate the MSTAR system in near real time will be demonstrated through the use of parallel super-computers in the R/T ATR Lab. Concurrently, a toolkit of interactive exploitation tools, integrated with commercial technology, will provide operationally useful ATR capabilities to image analysts. The rapid target model insertion project will demonstrate the ability to incorporate a new target model into the MSTAR system within two weeks, representing a five-fold improvement over 1997 MSTAR baseline rates. Perform feasibility analysis of advanced concepts for standoff identification of moving targets.
- AVS. ($ 7.789 Million)
  - The Airborne Video Surveillance (AVS) program will integrate, demonstrate and evaluate, extensively in laboratory systems and in some limited field experiments, airborne systems in simulated military missions with these technology goals: Activity Monitoring – upgrade to monitor activities (e.g., soldier movement, tactical and strategic vehicle movement) in larger areas and along extended lines

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

of communication; Moving Target Surveillance – demonstrate increased reliability of 3 target tracking/reacquisition and scaled development to track 6 targets; Precision Video Registration – Demonstrate 2 meter RMS error geolocation accuracy of 80% of mission imagery similar to reference imagery (Class 1: less than 40 degree line of sight variation, good contrast, small seasonal variations), demonstrate similar accuracy on 75% of imagery exceeding this envelope (Class 2). Activity Monitoring and Multiple Target Surveillance will perform focused experiments in support of Army and Air Force users to cause technology transition.

- Counter CC&D. ($ 31.200 Million)
  - The Counter CC&D Program will complete verification flights of FOPEN SAR on the Army RC-12 Airborne Demonstrator to verify that the system meets image quality and target detection requirements with real time tactical data link operational constraints. The Multi-Sensor Exploitation Testbed will be utilized to demonstrate and project Counter CC&D Exploitation capabilities in a CIGSS compliant architecture. Concept development studies and preliminary data collection experiments will be completed for FORESITE.

- AMSTE. ($ 25.000 Million)
  - The Affordable Moving Surface Target Engagement (AMSTE) program will leverage the exploratory work for precise engagement of moving surface targets that was begun under the MTE program. A weapon system trade study of "higher order" error terms and initial precision fire control tracking experiments will be completed. Multisensor registration, association and tracking algorithms will be developed, and iterative experimentation will be conducted using simulated and real multi-sensor GMTI data. Two multi-sensor data collections will be conducted to provide data for tracker analysis and to investigate coordination difficulties associated with netted tracking. The design work to support real-time networked precision fire control experiments will begin; the goal is to support at least two competing AMSTE contractors throughout the experimentation. Critical enabling technologies will begin development, including low cost weapon data links, automated endgame sensor control algorithms, and BDA/combat ID exploitation.

- Organic GMTI Radar (OGR). ($ 6.749 Million)
  - The Organic GMTI Radar (OGR) program will build and evaluate the brassboard proof-of-concept system. Additional data collection and propagation modeling efforts will lead to the selection of an operational frequency. Also, the fabrication of a low-cost full-scale receive array will be initiated. Planning for full scale testing and evaluation will begin. Studies using HDTV transmitters will be conducted.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

(U) **FY 2001 Plans:**

- AVS. ($ 6.000 Million)
  - The Airborne Video Surveillance (AVS) program will integrate, demonstrate and evaluate extensively in laboratory systems and in some limited field experiments, airborne systems in simulated military missions with these technology goals: Precision Video Registration – Demonstrate 2 meter RMS error geolocation accuracy on 90% of Class 1 and 80% of Class 2 imagery. Establish geolocation performance estimates over a wide array of global terrains for multiple algorithms.

- Counter CC&D. ($ 15.753 Million)
  - The Counter CC&D Program will perform user demonstrations of the FOPEN SAR on the Army RC-12 conducted with Army and Air Force exercises. Initial efforts to begin on rehosting MSET to SAIP residual for field demonstrations (Option). FORESITE development effort will begin.

- AMSTE. ($ 35.000 Million)
  - The Affordable Moving Surface Target Engagement (AMSTE) Program will continue the development of critical networked precision fire control GMTI tracking technologies. The detailed design and modification of existing system components will be completed to support multiple real-time precision fire control tracking experiments; the required sensor, data link, processor, battle management infrastructure, and target ground truthing modifications will be made. An initial capability to perform precision fire control tracking will be demonstrated using the airborne sensors modified under AMSTE. Field experimentation will be augmented with additional laboratory tracker evaluation. Additional subsystem modifications will continue to support subsequent AMSTE weapon system experimentation, including weapon modifications. If required, additional multiple platform GMTI data collections to support advanced GMTI precision fire control tracking will be conducted.

- Organic GMTI Radar (OGR). ($ 6.000 Million)
  - The Organic GMTI Radar (OGR) program will complete the laboratory acceptance testing of hardware and software, and field experimentation will begin. Experiments will occur at multiple sites using bistatic modes with dedicated transmitters and HDTV transmitters of opportunity. Initial ROC curves will be developed and multistatic phenomenology will be verified.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

- Eyeball. ($ 2.000 Million)
  - Analyze data on E-O, IR, and radar to support concept feasibility and system requirements.
  - Establish sensor limits and primary trades; investigate novel concepts for cross-cued E-O, IR and radar systems.
  - Explore feasibility to exploit microdoppler target signature data for identification purposes.
  - Complete preliminary design of demonstration system.

- Real-Time Synthetic Aperture Radar Battle Damage Assessment (R/T SAR BDA). ($ 7.000 Million)
  - The R/T SAR BDA program will pursue algorithmic techniques to provide near real-time, all-weather assessment of precision weapons effects on high-value mobile threat targets. This effort will investigate techniques to exploit change detection to identify weapons effects signatures in synchronized pre- and post-strike SAR imagery, and will couple this signature assessment with real time prediction of target functional degradation. Successful development of robust SAR BDA will permit more flexible and effective application of precision sensor-fuzed weapons from manned and unmanned platforms.

- STRIDE. ($ 4.000 Million)
  - Investigate performance prediction analysis, and develop novel object modeling technologies for Surface Target Recognition and Identification (STRIDE). Conduct experiment to verify gains of additional sensor degrees-of-freedom, including multi-look and wide dynamic range features.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

(U) **Schedule Profile:**

Plan	Milestones
Oct 99	Non-real-time precision fire control laboratory experiment.
Oct 99	AMSTE multiple platform GMTI data collection.
Oct 99	AVS field experiments: activity monitoring at a site; surveillance of 3 moving targets, geolocation (2-10 meter accuracy) of events.
Nov 99	Multi-Sensor Exploitation Testbed (MSET) Systems Integration Critical Design Review (CDR).
Nov 99	MSET registration plan developed.
Jan 00	Preliminary flight demonstration of FOPEN radar on manned platform.
Mar 00	Initial delivery of MSET MSI/SAR integrated tools.
May 00	FOPEN MTI/RFINT Concept Development Studies complete.
Jun 00	AMSTE weapon system trade studies concluded.
Jun 00	AMSTE multi-platform data collection.
Jun 00	Airborne demonstration of Airborne Video surveillance technologies.
Jul 00	Completion of "brassboard" OGR receive antenna.
Jul 00	Delivery of Refined MSET MSI/HIS/SAR Integrated Tools.
Jul 00	Participate in Army Warfighting Experiment.
Jul 00	FORESITE concept development studies complete.
Sep 00	AMSTE laboratory precision fire control experiment completed.
Sep 00	Verification of FOPEN SAR automatic target detection and cueing.
Sep 00	MSET integrated demonstration.
Sep 00	MSTAR demonstration of 25 different target types using full operational conditions and significant reduction in false alarm rates.
Oct 00	AVS precision video registration field experiments.
Oct 00	Completion of MSTAR Advanced Concepts evaluation.
Jan 01	STRIDE performance prediction studies and experiments.
Feb 01	Completion of Eyeball data collection plan, preliminary data analysis results.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Sensor and Guidance Technology PE 0603762E, Project SGT-04

Jul 01	Near Real-Time Implementation of MSET MSI/HSI/SAR integrated tools.
Jul 01	OGR field demo.
Sep 01	Initiate MSET re-host to SAIP residual for field demonstrations (Option).
Sep 01	User evaluation of FOPEN SAR operational utility.
Sep 01	AMSTE airborne precision fire control tracking experiment.
Sep 01	STRIDE Symposium.
Oct 01	AVS field experiments for user evaluations and technology transition.
Oct 01	Completion of Eyeball preliminary design.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Marine Technology PE 0603763E				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	24.779	22.538	34.964	48.396	55.896	55.696	60.496	Continuing	Continuing
Advanced Ship-Sensor Systems, MRN-02	24.779	22.538	34.964	48.396	55.896	55.696	60.496	Continuing	Continuing

(U) Mission Description:

(U) The objective of the Marine Technology Program is to identify, develop, and rapidly mature critical advanced technologies and system concepts for maritime applications that support the following goals: 1) enhancement of the ability of US naval forces to interrogate and dominate the maritime battlespace, particularly in the littoral arena; 2) improved power projection capabilities of US naval forces, particularly with respect to their ability to influence the land battle; 3) advances in the ability of US naval assets to conduct operations as a seamlessly networked and integrated theater level force; and 4) maintenance of US naval force access to the littoral by ameliorating the threat created by the worldwide spread of increasingly sophisticated technology. Proliferating threats such as modern cruise missile technology, commercially available overhead surveillance, advanced undersea mine capabilities, and modern, quiet diesel/electric submarines, pose major challenges for operations in the restricted water, near-shore regimes that are of growing importance to US strategic considerations, necessitating continued development of increasingly affordable far-term solutions for enhancing the operating capability and survivability margins of US naval forces in the littoral. This program element consists of a single project, Advanced Ship-Sensor Systems (MRN-02), comprised of the following programs: Undersea Littoral Warfare (ULW), Water Hammer, Buoyant Cable Array Antenna (BCAA), Robust Passive Sonar (RPS), and Fast Multimission Ship (FMS).

(U) The Undersea Littoral Warfare (ULW) program is developing the Netted Search, Acquisition, and Targeting (NetSAT) system, a networked approach for improved attack performance that exploits the use of a sonobouy field during the weapon run to identify, locate, and mitigate the impact of countermeasures and target evasion tactics on torpedo operation. A bi-directional fiber optic link enables return of torpedo information to a processor servicing the other sensors on the network in addition to providing a command link for the weapon. The ability to rapidly discern the geographic picture from multiple viewpoints is expected to provide major (10x) torpedo performance improvements in strong countermeasure environments while requiring only modest modification of existing torpedo inventories. Seamless coupling to a previously developed active acoustic search system (Distant Thunder) will provide significant enhancements at all points in the Anti-Submarine Warfare (ASW) attack chain. In addition, the ULW program is developing approaches to Synthetic Aperture Sonar (SAS) that would revolutionize our

ability to classify and identify underwater mines and improve search rates more than an order of magnitude greater than is possible with current techniques. A comprehensive proof of performance demonstration will be conducted to assure readiness for transition to formal development programs.

(U) The Water Hammer program is conducting concept development for a standoff mine neutralization system consisting of a phased array of shock tubes to generate, focus, and transport to militarily important distances (tens of meters) a pressure pulse of sufficient energy to neutralize the threat (>1000 psi-msec; >2000 psi). Water Hammer has the potential for rapid, precision, in-stride lane clearance in deep or shallow water, reducing the need for high fidelity detection and classification. While the initial program focuses on mine/obstacle clearance, Water Hammer also has general utility as a close-in defense system for ships against multiple classes of subsurface threats.

(U) The Buoyant Cable Array Antenna (BCAA) program is developing an antenna capable of supporting full duplex (transmit and receive) connectivity for voice and data with communications satellites while floating on the ocean's surface. Towed behind a submarine, this capability will enable high quality, high data-rate connectivity with other military assets, even while operating at speed and depth. Supporting technologies to be developed include photonic signal and power links, enhanced antenna loading materials, processing algorithms for blind adaptive array calibration and washover mitigation, advanced communications protocols, and signature minimization techniques. In addition, the feasibility of related approaches to radio frequency (RF) communications at higher frequencies in a package physically remote from the actual submarine platform will be assessed.

(U) The Robust Passive Sonar (RPS) program is an outgrowth of the successful experiments performed under the ULW program. The RPS program will investigate the ability of innovative, optimal processing approaches, coupled as appropriate to multi-dimensional receive arrays and/or external information, to precisely cancel the acoustic interference generated by surface shipping. At the lower frequencies that increasingly dominate submarine detection by acoustic means, shipping interference represents the primary noise background limiting the performance of existing sonar systems; this is especially true in the dense shipping environment typical of many littoral areas. Precise notching of shipping interference could result in net system performance gains of 10-20 dB, and the means of accomplishing it are expected to dictate preferred future array and acoustic sensor field designs. A data-driven program of algorithmic development and performance demonstration will be conducted as a multi-disciplinary effort. Participation across a broad spectrum of organizations in close coordination with Navy resources and organizations is intended.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Marine Technology PE 0603763E

(U) Fast Multimission Ship (FMS) is a project to develop an innovative high-speed, minimally manned combat vessel. This ship will be designed with drag reduction technology concurrently developed under program element 0601101E, MS-01, and will incorporate novel design attributes to enable high-speed operation in the littoral battlespace. Advanced automation systems will be incorporated to provide state-of-the-art situational awareness and connectivity while simultaneously minimizing crew. Given the operating space of the vessel, the ship will also incorporate signature reduction technology and innovative self-defense capabilities.

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Undersea Littoral Warfare (ULW). ($ 17.638 Million)
  - Completed initial prototype NetSAT system, integrating weapons control with countermeasures deconfliction.
  - Conducted laboratory testing to establish initial detection-to-attack performance enhancements provided by networked approaches.
  - Conducted engineering checkout of networked NetSAT hardware suite.
  - Conducted technical field testing of NetSAT prototype against submarine target.
  - Completed feasibility investigation of the Robust Passive Sonar processing and array concepts, utilizing geographically referenced processing and space-time processing (STP) techniques.

- Water Hammer. ($ 3.526 Million)
  - Continued non-explosive underwater energy projection technology development for mine neutralization, including fabrication and test of 4x4 source array test article.

- Buoyant Cable Array Antenna (BCAA). ($ 3.615 Million)
  - Conducted comparative testing of DARPA-generated BCAA concept and Navy-generated single element approaches in Ultra High Frequency (UHF) band; assessed cost/performance tradeoffs of differing approaches.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Marine Technology PE 0603763E

(U) **FY 2000 Plans:**

- Undersea Littoral Warfare (ULW). ($ 16.718 Million)
  - Update and complete development of prototype NetSAT system.
  - Conduct NetSAT operational proof of concept demonstration, including handover from advanced detection systems to the networked attack approach.
  - Complete testing of multi-frequency Interferometric Synthetic Aperture Sonar (IFSAS) and assess applicability to mine classification and high speed SAS operation.
  - Integrate end-to-end SAS processing chain in laboratory; commence development of advanced mine classification algorithms.
  - Commence integration of SAS testbed for proof of performance testing.
  - Assess potential Robust Passive Sonar (RPS) performance improvements in passive sonar from exploitation of external information (overhead surveillance and acoustic monitors).
  - Commence RPS development of space-time processing algorithms for advanced surface shipping interference rejection.

- Buoyant Cable Array Antenna (BCAA). ($ 5.820 Million)
  - Conduct component technology risk reduction and maturation.
  - Initiate design and development of a full duplex (transmit/receive) submarine BCAA prototype antenna; conduct preliminary design review.
  - Conduct risk mitigation testing of transmit link technologies.

(U) **FY 2001 Plans:**

- Undersea Littoral Warfare (ULW). ($ 6.564 Million)
  - Conduct final NetSAT operational demonstration.
  - Coordinate transition of NetSAT technologies to Navy.
  - Conduct Synthetic Aperture Sonar (SAS) data collection exercises; complete SAS classification performance assessment.
  - Coordinate transition of SAS technologies to Navy.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Marine Technology PE 0603763E

- Bouyant Cable Array Antenna (BCAA). ($ 7.100 Million)
  - Complete algorithm and software development for space-time adaptive communications link processor.
  - Complete design of BCAA prototype antenna; conduct critical design review.
  - Fabricate BCAA prototype antenna; commence integration with submarine deployment and retrieval systems.
  - Assess feasibility of remotely operated antenna concepts for improving submarine stealth while providing round-the-clock two-way communications.

- Robust Passive Sonar (RPS). ($ 10.300 Million)
  - Continue development of space-time processing algorithms for advanced surface shipping interference rejection.
  - Conduct initial data collection field exercises.
  - Create baseline integrated interference rejection processing stream; conduct preliminary performance assessment.

- Fast Multimission Ship (FMS). ($ 11.000 Million)
  - Develop ship structural concept by exploiting innovative hullform designs and active drag reduction technology in a balanced design.
  - Assess advanced technologies for self-defense, including passive, active, and reactive approaches.
  - Initiate development of innovative automation systems to minimize shipboard personnel requirements.
  - Explore innovative applications in a networked environment.

(U) **Program Change Summary:** (*In Millions*)

	FY1999	FY 2000	FY 2001
Previous President's Budget	23.659	22.538	21.964
Current Budget	24.779	22.538	34.964

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Marine Technology PE 0603763E

(U) **Change Summary Explanation:**

FY 1999 Increase reflects minor repricing and completion of Anti-Submarine Warfare Netted Search, Acquisition and Targeting (NetSAT) effort.

FY 2001 Increase reflects emphasis on the advanced technology associated with the development of drag reduction and innovative automation systems to minimize crew complement under the Fast Multimission Ship Program.

(U) **Other Program Funding Summary Cost:**

Not Applicable.

(U) **Schedule Profile:**

Plan	Milestones
Undersea Littoral Warfare (ULW):	
Sep 99	Conduct initial demonstration of prototype NetSAT system (targeting and attack only) in a controlled test range environment.
Sep 99	Complete quantitative feasibility assessment of geographically referenced space-time processing approach.
Dec 99	Complete interferometric synthetic aperture sonar (IFSAS) sea test; complete feasibility assessment of short aperture SAS processing.
Sep 00	Conduct NetSAT sensor-to-shooter operational demonstration including surveillance, detection, handoff, targeting and attack in a countermeasure environment.
Sep 00	Initial end-to-end SAS processing chain complete.
Jun 01	Conduct follow-on NetSAT operational demonstration.
Sep 01	SAS classification performance assessment complete.
Water Hammer:	
Dec 99	Complete fabrication of 4 x 4 Water Hammer source array as second test article.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Marine Technology PE 0603763E

Buoyant Cable Array Antenna (BCAA):

Sep 99	Finalize BCAA concept at Ultra High Frequency (UHF).
Jun 00	Conduct Preliminary Design Review (PDR) for BCAA prototype system.
Dec 00	Conduct Critical Design Review (CDR) for BCAA prototype system.
Mar 01	Conduct feasibility assessment for remotely operated submarine communications concepts.
Sep 01	BCAA multi-element antenna prototype system complete.

Robust Passive Sonar (RPS):

Mar 00	Exploitation of external information feasibility assessment complete.
Mar 01	Initial RPS data collection field exercise complete.
Jun 01	Baseline interference rejection processing stream for passive sonar created.
Sep 01	Preliminary RPS performance assessment complete.

Fast Multimission Ship (FMS):

Jun 01	Initial hullform concept for FMS developed.
Sep 01	Self-defense technology assessment for FMS complete.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E				

COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	85.299	97.825	91.267	92.177	77.000	87.000	87.000	Continuing	Continuing
Rapid Strike Force Technology LNW-01	43.632	53.223	52.867	56.177	47.000	42.000	42.000	Continuing	Continuing
Small Unit Operations LNW-02	41.667	44.602	38.400	36.000	30.000	45.000	45.000	Continuing	Continuing

(U) **Mission Description:**

(U) This program element is budgeted in the Advanced Technology Development Budget Activity because it is developing and demonstrating the concepts and technologies that will address the mission requirements of the 21st Century land warrior. Two broad efforts are being pursued in support of this objective: Rapid Strike Force Technology and Small Unit Operations.

(U) The Rapid Strike Force Technology project is developing the technologies necessary for highly mobile, covert transportation and information gathering systems to enhance U.S. early-entry capabilities. The primary thrusts of this project include: 1) the Reconnaissance, Surveillance and Targeting Vehicle (RST-V) program that will design, develop, test and transition a minimum of four hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles to the Services; 2) the Solar Blind Detectors program that will develop technologies to enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles; 3) the Tactical Mobile Robotics (TMR) program that will develop mobile robotic technologies that will enable land forces to dominate battlespace using individual, or teams, of mobile robots in complex terrain; 4) the Mobile Tactical Operation Center/Future Ground Combat System program that will explore and develop technologies to be used by tactical commanders in situational awareness, communications and control; and 5) the Metal Storm program that will develop a system to pack, transport and fire at variable sequence rates.

(U) The Small Unit Operations project is developing the critical technologies that will enable dispersed units to effectively perform warfighting operations that traditionally have required massed forces. Technology development efforts will focus on a comprehensive awareness capability that provides real-time, essential information for small units and individual warfighters; wireless communication technologies to permit exchange of voice, digital and video data with other systems; geolocation technologies that provide navigation information in built-up, forested and

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E

mountainous environments; internetted tactical surveillance and targeting sensors to complement information requirements not satisfied by national, theater and component sensor programs; and automated ultra-miniature imaging and non-imaging sensors.

(U) **Program Change Summary:** (*In Millions*)

	FY1999	FY 2000	FY 2001
Previous President's Budget	88.613	97.825	101.376
Current Budget	85.299	97.825	91.267

(U) **Change Summary Explanation:**

FY 1999 Decrease reflects SBIR and other minor below threshold reprogrammings.

FY 2001 Decrease reflects reduction in scope of the Situational Awareness System, partially offset by increase for such programs as Wolfpack.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)							DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01				

COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Rapid Strike Force Technology LNW-01	43.632	53.223	52.867	56.177	47.000	42.000	42.000	Continuing	Continuing

(U) **Mission Description:**

(U) The emerging US vision of future land warfare places strong emphasis on technology supporting early entry of light, efficient, land forces. This project is developing technologies that enable mobile and survivable systems for efficient command and control, mobility, surveillance, targeting and reconnaissance, which are important aspects of an early-entry capability. The project consists of: Combat Hybrid Power Systems (CHPS); Reconnaissance, Surveillance, and Targeting Vehicle (RST-V); Tactical Mobile Robotics (TMR); Solar Blind Detectors; Countersituational Awareness (CSA); and a Future Ground Combat System that will include a Mobile Tactical Operations Center (M-TOC). The CHPS, RST-V, M-TOC and TMR programs are closely coordinated with the US Army, Navy, and Marine Corps, and with DARPA's Electric Vehicle (PE 0603747E) and Small Unit Operations (LNW-02) projects.

(U) The Combat Hybrid Power System program will develop enabling technologies and conduct demonstrations of an integrated hybrid electric power system that provides power and energy management for all of the electric subsystems throughout future combat vehicles. Hybrid electric power is an essential enabling technology for future combat vehicles given the number of electrically powered subsystems planned for implementation. The hybrid electric power system will consist of an engine/alternator, sized for average power demand, energy storage and power averaging components that provide both continuous and pulsed power, distribution networks, subsystem controls, and power conditioning devices. Vehicles of various configurations and for a variety of missions will be simulated to evaluate subsystem requirements, topologies, and military utility. The simulated vehicle concepts will demonstrate greatly reduced noise and thermal signatures; improved mobility, survivability, lethality, and fuel economy; optimized interior layouts; significantly reduced volume and weight. These advantages will result in deployable, affordable combat vehicles that meet mission requirements.

(U) The Reconnaissance, Surveillance, and Targeting Vehicle (RST-V) program will design, develop, test/demonstrate, and transition to the Services four hybrid electric drive, lightweight, highly maneuverable advanced technology demonstrator vehicles capable of V-22 internal transport. The vehicle will incorporate technological advancements in the areas of integrated survivability techniques and advanced suspension. The vehicle will also host integrated precision geolocation, communication and Reconnaissance, Surveillance and Targeting (RST) sensor subsystems. The RST-V platform will provide a mobile quick deployment and deep insertion capable, multi-sensor, battlespace awareness asset for small unit tactical

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

reconnaissance teams, fire support coordinators, and special reconnaissance forces. Critical components and technologies include a high efficiency, reduced signature hybrid electric propulsion system with increased fuel economy; an advanced suspension to increase cross-country speed and provide platform stabilization; an advanced integrated survivability suite; and the capability to operate in either a silent watch/silent movement or mechanical mode. The vehicle will incorporate modularized design components to allow for signature management and rapid reconfiguration for mission tailoring and multiple purpose utility. Hardware and lessons learned from this program directly support the Marine Corps-Navy Extending the Littoral Battlespace (ELB) ATD as well as address Joint United States Marine Corps – Special Operations Command (USMC-SOCOM) requirements for the Internally Transportable Vehicle/Light Strike Vehicle (ITV/LSV) and Tactical Vehicle, Reconnaissance, Surveillance, Targeting and Acquisition (TV-RSTA) program and High Mobility Multi-purpose Wheeled Vehicle (HMMWV) upgrades. The Marine Corps will develop vehicle concepts and chassis, integrate the DARPA developed components, and conduct vehicle performance tests (PE 0603640M) through participation in scheduled Advanced Warfighting Experiments (AWEs) and Advanced Concept Technology Demonstrations (ACTDs) (e.g. Capable Warrior).

(U) The Tactical Mobile Robotics (TMR) program will develop mobile robotic technologies that will enable land forces to dominate the battlespace through employment of mobile semi-autonomous robot teams performing challenging missions in complex environments (dynamic urban areas, rugged terrain with high obstacle clutter, etc.). TMR will provide DoD organizations with semi-intelligent, cooperating platforms carrying a variety of integrated mission payloads required to conduct activities in risk intensive or inaccessible areas. Operational emphasis is on urban environments and denied areas. Specific robot technologies that will be advanced include: perception, autonomous operation, and advanced locomotion for complex obstacle negotiation. Perception capabilities will include: (a) an on-board multi-sensor perception system capable of detecting at least 80 percent of decimeter-scale terrain hazards and at least 95 percent of meter-scale terrain hazards, both at 20 Hz and (b) multi-source mapping algorithms capable of creating topological maps of urban structures with 90 percent accuracy. Autonomous operation capabilities will include: (a) coordination of the tactical behavior of a multi-robot team with significant command cycle reduction, and (b) traversal of rugged/complex terrain using 1 command per 100m of travel. Locomotion capabilities will feature portable (sub-meter-scale) vehicles traveling up to 1 m/s over 25 cm steps and decimeter-scale rubble.

(U) The Solar Blind Detectors program (formerly titled "Vehicle Self-Protection") will develop an Ultraviolet (UV) solar blind solid state focal plane array to significantly enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles at greatly reduced cost.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

(U) The Future Ground Combat System ("Vehicle") (FGCS) program will develop network centric concepts and land warfare technologies to prototype a lightweight Multi-Mission Combat System (MMCS) that will be overwhelmingly lethal, strategically deployable, self-sustaining and highly survivable. The FGCS will stress integrated command and control capabilities with unsurpassed situational understanding for all levels of commanders. This system will be transitioned to the U.S. Army for full development and ultimate deployment in 2015. A Future Ground Combat System ("Vehicle") will be a multi-functional, multi-mission re-configurable system of systems to maximize joint operability, strategic transportability and commonality of mission roles including direct and indirect fire, air defense, reconnaissance, troop transport, counter mobility, non-lethal, and C2 on the move. The goal of this effort is to develop a network centric advanced force structure, quantify its benefits and identify material solutions and technologies within the context of that force. It will also identify Doctrine, Operational, Training, Leader and Material (DOTLM) specific changes necessary as a result of the development of this network centric advanced force structure.

(U) The Mobile Tactical Operations Center (M-TOC) program will develop concepts and technologies to enable a battalion level commander and lower to control organic surveillance assets and fire support while on the move. MTOC will develop technologies needed to allow high-performance exploitation and fusion of varied data products by a commander. Enhanced visualization, communication, and weapon programs currently on-going and planned at DARPA will be leveraged. Results from this program will be used in the development of the multi-mission combat system or Future Ground Combat System ("Vehicle").

(U) The Metal Storm (MS) program will develop a unique 100 percent solid state system for tightly packing, transporting, and firing projectiles in multiple tubes with high or low pressures, in an electronically infinitely variable sequence rate with applications to small arms and crew served weapons. The program facilitates current US force reduction and restructuring policies while increasing firepower. The program will demonstrate revolutions in weapon design and application that will far exceed the effectiveness and versatility of existing small arms and large munitions weaponry and will primarily focus on developing, fabricating and testing two 7.62 mm sniper rifle prototypes for SOF use. The design will incorporate a multi-barrel configuration allowing instant access to a variety of projectiles. Studies will be conducted to optimize propellants and projectiles; to examine electronic keying, silencing and underwater operations; and to investigate the physics of scaling from a small caliber, low pressure design to a large caliber (40 and 81mm), modest barrel pressure (~60,000 psi) design. Through a Project Arrangement under the Deutsch Ayers Agreement between the US and Australia, the Defence Science & Technology Office (DSTO) will perform work in the areas of scaling, modeling and simulation, and small arms live fire testing.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

(U) **<u>Program Accomplishments and Plans:</u>**

(U) **<u>FY 1999 Accomplishments:</u>**

- Combat Hybrid Power Systems (CHPS). ($ 15.346 Million)
  - Installed and integrated hybrid electric power components in the Systems Integration Laboratory (SIL).
  - Conducted tests that demonstrated simultaneous operation of pulsed and continuous loads in the laboratory and verified virtual prototype models for selected components.
  - Completed design and initiated fabrication of advanced, high-risk power system components (critical enabling technologies) in particular, Lithium Ion batteries and Silicon Carbide based power electronics module.
  - Demonstrated hardware-in-the-loop virtual prototype.

- Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). ($ 6.217 Million)
  - Completed Critical Design and conducted Critical Design Review of both RST-V team designs.
  - Down selected to one contractor.
  - Finalized design and conducted Fabrication Readiness Review.
  - Refined development of automotive subsystems.
  - Evaluated emerging technologies for high data rate covert communications.

- Tactical Mobile Robotics (TMR). ($ 16.254 Million)
  - Refined advanced employment concepts to exploit portable robot potential and accommodate expanded user interest.
  - Demonstrated breadboard robot perception, autonomy, and obstacle negotiation (stair climbing) in challenging mission scenarios.
  - Completed and evaluated competing designs for integrated robotic system.
  - Refined system design and employment plans to exploit progress made with enabling technologies and accommodated multiple collaborating platform employment where practical.
  - Evaluated advanced communication and control techniques.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

- Solar Blind Detectors Program. ($ 4.815 Million)
  - Initiated development of an Ultraviolet (UV) solar blind solid state focal plane array to significantly enhance the survivability of mobile ground vehicles against the threat of advanced tactical guided missiles at greatly reduced cost.

- Advanced Concepts Evaluation. ($ 1.000 Million)
  - Conducted technology assessment and feasibility testing of advanced rapid strike force concepts in the areas of battlefield communications and asset control, autonomous systems, fire support, and situational awareness.

(U) **FY 2000 Plans:**

- Combat Hybrid Power Systems (CHPS). ($ 10.319 Million)
  - Install the completed, advanced, high-risk hybrid electric power system components in the Systems Integration Laboratory (SIL).
  - Continue test and evaluation of integrated hybrid electric power system and subsystems.
  - Investigate and quantify benefits of hybrid electric power for future combat vehicles using SIL and virtual prototype.
  - Continue development of and exercising the vehicle virtual prototype.
  - Investigate alternative critical power system component technologies.
  - Develop coordinated plan for continued effective utilization of CHPS SIL and virtual prototypes.
  - Transition CHPS program to U.S. Army Tank-Automotive and Armaments Command (TACOM).

- Solar Blind Detectors Program. ($ 5.886 Million)
  - Demonstrate low defect epitaxial material compatible for photodetectors with high sensitivity operating in the solar-blind region of the spectrum (240-300 nm).

- Future Ground Combat System ("Vehicle") (FGCS). (Formerly Mobile Tactical Operations Center (M-TOC)). ($ 7.000 Million)
  - Develop force level concepts and integrated development environment.
  - Evaluate and brassboard technologies for connectivity, exploitation, and interface protocols.
  - Develop standard threat scenarios and understand requirements for Command, Control, and Exploration systems.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

- Tactical Mobile Robotics (TMR). ($ 15.719 Million)
  - Initiate development of fully functional tactical robotic platforms.
  - Integrate enabling technologies into functional platforms.
  - Refine demonstration and transition plans commensurate with success in system design and multi-platform collaboration.

- Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). ($ 11.299 Million)
  - Perform wheelmotor qualification tests.
  - Roll out vehicles 1 and 2.

- Advanced Concepts Evaluation. ($ 3.000 Million)
  - Conduct technology assessment and feasibility testing of advanced rapid strike force concepts including precision guided munitions, force-on-force modeling, covert autonomous sensors, and future unmanned vehicle systems.
  - Conduct studies to optimize the Metal Storm concept, research propellants and projectiles, and develop approaches to enhance accuracy.

(U) **FY 2001 Plans:**

- Solar Blind Detectors Program. ($ 4.425 Million)
  - Demonstrate solar-blind detector array with 128 x 128 pixels.

- Tactical Mobile Robotics (TMR). ($ 10.060 Million)
  - Complete integrated robotic system development and testing.
  - Conduct operational demonstrations with integrated systems.
  - Initiate transition to military departments.

- Reconnaissance, Surveillance, and Targeting Vehicle (RST-V). ($ 7.282 Million)
  - Deliver vehicles 1 and 2 for participation in United States Marine Corps (USMC) Advanced Warfighting Experiment.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

- Integrate and demonstrate Survivability Suite.
- Deliver vehicles 3 and 4.

• Future Ground Combat System ("Vehicle") (FGCS). ($ 22.200 Million)
- Develop system and force design concept options, including component level dimensionality, functionality and level performance allocation to specific emerging technologies, and operational concepts for employment of the FGCS.
- Populate force level models to be used for the evaluation of concept options.
- Preliminary design of ground combat systems.
- Exploration and development of reliable mobile command and control technologies, including antennas and communications suites.
- Development of prototype exploitation and situational awareness technology.

• Metal Storm (MS). ($ 8.900 Million)
- Demonstrate a single barrel, high rate of fire, electronically keyed rifle.
- Develop designs for silenced and underwater operations.
- Perform modeling studies of lethality and penetration requirements.

(U) **Other Program Funding Summary Cost:**

	FY1999	FY2000	FY2001
PE 0603640M Marine Corps Advanced Technology	2.8	3.0	2.7
PE 0603005A Combat Vehicle and Automotive Advanced Technology	0.0	4.7	4.7

(U) **Schedule Profile:**

Plan	Milestones
Sep 99	Defined system design for selected platforms (TMR).
Oct 99	Complete advanced concepts evaluation studies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-01

Oct 99	Demonstrate simulations operations of engine, dyno motors, flywheel, batteries, and pulse forming network in Systems Integration Laboratory (SIL).
Dec 99	Electric drive checkout (RST-V).
Jan 00	Conduct Preliminary Design Review (PDR) and begin fabrication of selected TMR platforms (TMR).
Mar 00	Preliminary Design Review (PDR) for single barrel high rate of fire device (Metal Storm).
May 00	Validated physics mode (CSA).
Jul 00	Integrate advanced components and demonstrate fully integrated combat hybrid power system laboratory (CHPS).
Jun 00	Vehicle 2 rollout (RST-V).
Jul 00	Conduct final technology demonstration and Critical Design Review (CDR) for selected TMR platforms (TMR).
Jul 00	Define communication deception node system architecture.
Sep 00	Preliminary Design of Integrated Virtual Environment (M-TOC).
Sep 00	Preliminary Design on Threat Scenario (Mobile Tactical Operations Center (M-TOC)).
Sep 00	Configure system for Service transition (Combat Hybrid Power System (CHPS)).
Oct 00	Deliver vehicles 1 and 2 (RST-V).
Jan 01	Demonstrate RST-V system capabilities in Advanced Warfighting Experiment (AWE). (RST-V).
Mar 01	Demonstrate Avalanche Photodetector (APD) array with 100 amps/watt responsity and low dark current.
Apr 01	Complete physics of scaling study (Metal Storm).
Jun 01	Integrated Survivability demonstration of Reconnaissance, Surveillance, and Targeting Vehicle (RST-V).
Jul 01	Complete operational demonstrations of Tactical Mobile Robotic (TMR) systems. Initiate transition and technology transfer plans (TMR).
Aug 01	Complete Initial Force Level Concept Designs and perform Force Level Concept Design Analysis (Multi-Mission Combat System/Future Combat Vehicle (MMCS/FCV)).
Sep 01	Downselect to 2 Force Level Designs (MMCS/FCV).
Sep 01	Preliminary Design Review (PDR) for multibarrel device (Metal Storm).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development				R-1 ITEM NOMENCLATURE Land Warfare Technology PE 0603764E, Project LNW-02					
COST *(In Millions)*	FY 1999	FY 2000	FY 2001	FY 2002	FY 2003	FY 2004	FY 2005	Cost to Complete	Total Cost
Small Unit Operations LNW-02	41.667	44.602	38.400	36.000	30.000	45.000	45.000	Continuing	Continuing

(U) **Mission Description:**

(U) The Services are pursuing new tactical concepts for employing small, easily deployed units as an early entry force to address future contingencies. Their objective is to enable these forces to quickly control a large battlespace with dispersed forces, control the operational tempo, engage enemy targets with remote fire and operate effectively across the spectrum of conflict in severe communications environments. These dismounted forces must be self-sufficient, capable of operating for several days and be sufficiently lean to be quickly inserted anywhere in the world.

(U) Superb situational awareness is critical to the combat effectiveness and survivability of such forces. Each small team must constantly know where it is, where the other teams are and where the enemy and any other threat is located. The Services are developing lightweight radio communications and Global Positioning System (GPS) dependent geo-positioning systems packaged into fielded capabilities such as the Land Warrior System. In addition, advanced standoff sensor systems such as Predator, Global Hawk and Discoverer II are being developed to monitor the enemy's movements and characterize the battlespace. These capabilities will greatly improve the combat effectiveness of small dismounted forces, but will be limited to operations in open areas under benign conditions. Current communications, navigation and sensor technology is poorly configured to operate in urban areas (outside or inside buildings), in jungles, forests or mountainous terrain. Communications technology is susceptible to enemy jamming or unintentional radio interference and is not covert to intelligence operations. Extant sensors and exploitation capabilities are limited to broad area surveillance of vehicles and facilities; data is not mined and distributed to forces at the lowest echelon.

(U) The objective of the Small Unit Operations Project is to develop critical technologies that will enable small dismounted forces to effectively fight anywhere, anytime. The technology needs are: semi-automated maneuver and strike/fire planning and re-planning that can be employed by commanders who are physically separated but need to be virtually collocated; automated fusion and mining of information sources to provide a "bubble" of awareness over each warrior and team describing the relevant situation; accurate geographic position estimation, other than GPS, which works in all environments; and radio links and ad hoc networked communications that "glue" the components together, operates in any environment, is covert and resistant to interference. In addition, these technologies must not significantly increase the dismounted force's mass and power burden. The programs that make up this project include the Situational Awareness System (SAS), Tactical and Laser Acoustic Sensors, Optical Tags, Wolfpack and the Boring and Navigation Program (BNP).

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology 0603764E, Project LNW-02

(U) The Situation Awareness System (SAS) will integrate these technologies into a 1 kg module (plus 0.5 kg per day for the power source) worn by the individual warrior. The Agency module will be interoperable with the Army Land Warrior equipment and provide much greater functionality at significantly less weight. The warrior module will provide the communications and computing power to fully interconnect the dismounted force and enable situation awareness information to be distributed, as well as support continuous planning and combat execution. The Geolocation Technology Program will develop and demonstrate precision miniature clocks, a low-power Global Positioning System (GPS) receiver/processor (2 joules per fix) and a digital LORAN receiver to provide the accurate navigation and targeting needed for small unit operations.

(U) The Situation Awareness System (SAS) program will investigate the critical SAS performance parameters with in-depth experiments. It will provide user-centered design input for developers and provide an independent assessment of the SAS design. The experiments will be focused to evaluate the sensor employment, validate network robustness and reliability, and conduct a scenario-focused evaluation of geolocation and navigation requirements in urban, forested and mountainous terrain. It will also acquire and codify knowledge of dispersed land forces tactics to develop decision aids and evaluate the utility of the aids for small units. Specialized tools will be developed to generate scenario-synchronized data for development and evaluation of the Situation Awareness System functions. The program will coordinate the use of testing infrastructure to conduct evaluations and assessment and will employ a combination of military and technical subject matter experts, computer modeling and simulation tools, and laboratory and field exercises, to provide independent validation of the SAS functionality.

(U) The Tactical Sensors program will develop new sensor system technologies that will provide the warfighter with a capability to detect, track, and classify mobile tactical targets and to characterize fixed, man-made structures. These sensor systems provide a local, in-situ sensing capability near high value targets or at choke points in denied areas. Information provided by these sensors can be fused with other longer-range space, airborne, and ground sensor systems to enhance the aggregate surveillance and tracking capabilities of US forces. Applications include surveillance, cueing, precision targeting, intelligence and battle damage assessment with respect to time critical, mobile targets (vehicles and humans) and to fixed man-made structures (surface and underground facilities).

(U) The Laser Acoustic Sensors program will develop a completely new class of laser acoustic sensors for military surveillance and targeting applications. These sensors will provide surveillance, target detection, tracking, classification, cueing, and bomb damage assessments at distances 10X greater than current capabilities. The acoustic sensor will use a virtual acoustic array generated by angle scanning and range gating a laser beam in the atmosphere. Natural aerosols in the virtual array are displaced by the acoustic pressure wave generated by the target, thereby providing a phase modulated backscatter of the laser energy that is detectable by the receiver. A recent breakthrough in defining atmospheric turbulence cells with unique, fine structure Doppler spectrum permits visibility and access to the target acoustic signature sideband structure.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology 0603764E, Project LNW-02

(U) The Optical Tags Program will investigate nonlinear optical technologies and innovative design and fabrication techniques for kilometer-range optical tag systems, which provide a quantum leap in tactics and operations in a wide variety of applications. The Optical Tags Program will develop validated models to predict system performance in support of a selected set of applications for technology demonstration. The program will select a relatively mature application, such as marking or tagging, and a relatively immature application, such as precision strike. The applications will be selected based on their operational significance and user input. The Optical Tags Program will perform system engineering to develop systems performance requirements for the applications and will demonstrate the systems in meaningful warfighter experiments.

(U) The Wolfpack Program will develop technologies that would enable the U.S. to deny the enemy use of radio communications throughout the battlespace. This will culminate in a networked system of air emplaced, autonomous, ground-based monitors/jammers linked together to cooperate and avoid disruption of friendly military and protected commercial radio communications. The specific technologies to be developed include: (1) high efficiency sub-resonant antennas, (2) networking algorithms to allow coordinated access to the spectrum by communicators, jammers and SIGINT systems, (3) methods to easily deploy the systems high terrain high points, and (4) algorithms to rapidly, and autonomously detect, classify, identify and jam target signals with low power electronics.

(U) The Boring and Navigation Program (BNP) will develop new technologies to allow a subterranean probe to navigate precisely in three dimensions. This system will be light and affordable so as to be deployable by small units or special operation forces. Primary applications include use in search and rescue operations in collapsed buildings and surveillance for military Operations-Other-Than-War (OOTW).

(U) **Program Accomplishments and Plans:**

(U) **FY 1999 Accomplishments:**

- Situational Awareness System (SAS). ($ 27.235 Million)
  - Assessed advanced concepts and technologies for dispersed land forces applications.
  - Completed developments for the situation awareness and real time tasking and control technologies.
  - Completed technology development for tactical communications capability.
  - Completed evaluation of enabling technologies associated with Situation Awareness System (SAS) design and conducted breadboard demonstration of critical communications and geolocation technologies.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology 0603764E, Project LNW-02

- Completed detailed design of SAS and began development of Situation Awareness brassboard system.
- Down-selected contractor and awarded an Other Transaction Agreement for SUO Phase 3 Development.

• Tactical Sensors. ($ 13.124 Million)
- Continued development of internetted remote control sensors to detect, localize and characterize targets.
- Continued development of surveillance and targeting sensors systems for dispersed operations, including laser acoustic sensor phenomenology modeling and breadboard design.

• Laser Acoustic Sensors. ($ 1.308 Million)
- Established feasibility of concept by extracting low frequency acoustic signals in natural air.
- Initiated development of laser acoustic breadboard sensor.

(U) **FY 2000 Plans:**

• Situational Awareness System. ($ 32.803 Million)
- Complete development of the Individual Warfighter Situation Awareness System (IWSAS), Warfighter Tactical Associate (WTA)-Base, WTA Mobile, and Relay/Router/Beacon detailed hardware design, software modules and network protocols.
- Complete Individual Warfighter/WTA software coding.
- Complete IWSAS, WTA-Base, WTA-Mobile, Relays and network code development and testing.
- Complete situation awareness (planning, tasking, sensor control, navigation and alerts) application software coding and testing.
- Complete brassboard fabrication of the major SAS elements (IWSAS, WTA and Relays).
- Conduct performance assessment of (SAS) Phase 3 brassboard design.
- Verify that Individual Warfighting Situation Awareness System (IWSAS), Warfighter Tactical Associate (WTA) and Relay Radio Frequency (RF) propagation in multipath, jamming and open environments meets 99 percent service availability objective.
- Verify geolocation accuracy and navigation performance in urban and field environments.
- Develop Wolfpack system architecture and conduct system level trades to develop sub-system requirements.
- Determine the optimum use of legacy systems for IPB and cueing and potential modifications required for coordinated spectrum access.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology 0603764E, Project LNW-02

- Tactical Sensors. ($ 6.859 Million)
  - Continue development of internetted remote control sensors to detect, localize and characterize targets; continue development of surveillance and targeting sensors systems for dispersed operations.

- Laser Acoustic Sensors. ($ 2.940 Million)
  - Complete and test laser acoustic breadboard sensor and initiate brassboard development.

- Optical Tags. ($ 2.000 Million)
  - Conduct technology development for a kilometer-range optical tag system.
  - Select a relatively mature application and develop optical tag requirements.
  - Select a relatively immature application and develop contractor team.

(U) **FY 2001 Plans:**

- Situational Awareness System. ($ 13.400 Million)
  - Complete fabrication of Individual Warfighting System Situational Awareness System (IWSAS), Warfighter Tactical Associate (WTA) Mobile and Base, tactical sensors and tactical relays for test.
  - Integrate IWSAS, WTA-Mobile and Base with external legacy communications, data and sensor equipment.
  - Test integrated system and conduct performance assessment of final Phase 3 design; measure (IWSAS), (WTA) and Relay Radio Frequency (RF) propagation in multipath, jamming and open environments meets 99 percent service availability objective.
  - Complete development of detailed demonstration scenarios to test and evaluate performance under operational conditions.
  - Perform setup of SAS field demo.
  - Develop training materials and conduct soldier training for field demo.

- Tactical Sensors. ($ 8.000 Million)
  - Continue development of internetted remote control sensors to detect, localize and characterize targets.
  - Continue development of surveillance and targeting sensors systems for dispersed operations.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology 0603764E, Project LNW-02

- Laser Acoustic Sensors. ($ 3.000 Million)
  - Complete laser acoustic brassboard and initiate 2D fieldable sensor development.

- Optical Tags. ($ 5.000 Million)
  - Demonstrate a kilometer-range optical tag system.
  - Predict tag performance for relatively mature application.
  - Develop requirements and predict tag performance for relatively immature applications.

- Wolfpack. ($ 6.000 Million)
  - Complete system design and performance analysis.
  - Conduct proof-of-concept demonstrations of high-speed signal detection and identification algorithms.
  - Verify low duty cycle, low power jamming techniques with benchtop experiments.

- Boring and Navigation Program. ($ 3.000 Million)
  - Initiate development and assessment of techniques for producing an accurate three-dimensional geolocation underground.
  - Conduct initial "laboratory-quality" tests to assess preliminary accuracy.

(U) **<u>Other Program Funding Summary Cost:</u>**

- Not Applicable.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology 0603764E, Project LNW-02

(U) **Schedule Profile:**

Plan	Milestones
Situational Awareness System:	
Nov 99	Demonstrate brassboard SAS network design.
Feb 00	Complete SAS critical design review.
May 00	Complete SAS software coding.
Jun 00	Complete SAS sensor and weapon simulant.
Jul 00	Complete brassboard SAS integration and test.
Mar 01	SAS components fabricated.
Tactical Sensors:	
May 00	Demonstrate Miniature Infrared Camera (MIRC).
Aug 00	Demonstrate brassboard integrated micro-(UGS) system.
Sep 01	Complete micro-UGS field demonstration tests.
Laser Acoustic Sensors:	
Dec 99	Demonstrate laser acoustic signal processing and wind tests.
Sep 00	Demonstrate laser acoustic final breadboard.
Sep 01	Demonstrate laser acoustic final brassboard.
Optical Tags:	
Dec 99	Technology development award.
Dec 99	Application contractor awards.
Jun 00	Mature application requirements developed.
Sep 00	Less mature application developed.
Mar 01	Mature application performance predicted.
Jun 01	Less mature application requirements developed and performance predicted.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA3 Advanced Technology Development	R-1 ITEM NOMENCLATURE Land Warfare Technology 0603764E, Project LNW-02

Wolfpack:

Jun 00	System specifications and performance analysis complete.
Sep 00	Award integration contract.
Mar 01	Initial enabling technology demonstrations.
Jun 01	Single sensor performance verified in laboratory.

Boring and Navigation Program:

Aug 01	Test and determine the three-dimensional, subterranean, geolocation accuracy anticipated from multiple innovative techniques.

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)								DATE September 1999	
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support					R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E				
COST *(In Millions)*	FY 1999	FY2000	FY2001	FY2002	FY2003	FY2004	FY2005	Cost To Complete	Total Cost
Total Program Element (PE) Cost	32.898	31.387	34.632	35.944	37.373	38.634	38.922	Continuing	Continuing
Management Headquarters (R&D) MH-01	32.898	31.387	34.632	35.944	37.373	38.634	38.922	Continuing	Continuing

(U) Mission Description:

(U) This program element is budgeted in the Management Support Budget Activity because it provides funding for the administrative support costs of the Defense Advanced Research Projects Agency. The funds provide personnel compensation for civilians as well as costs for building rent, physical and information security, travel, supplies and equipment, communications, printing and reproduction. In addition, funds are included for reimbursing the military services for administrative support costs associated with contracts undertaken on the agency's behalf.

(U) Program Accomplishments and Plans:

(U) FY 1999 Accomplishments:

- DARPA continued to fund management and administrative support costs. In FY 1999, salary requirements for Intergovernmental Personal Act (IPA) appointments were moved to program funds in lieu of being centrally funded in this program element. The FY 1999 additional salary requirements associated with DARPA's expanded hiring authority (Section 1101 of the FY 1999 Authorization Act) partially offset the IPA salary transfer. ($ 32.898 Million)

(U) FY 2000 Plans:

- DARPA will continue to fund civilian direct-hires and administrative support service costs. Salary reimbursement for IPAs remains funded with program funds in keeping with OMB policy. Reductions associated with this change have been substantially offset by the additional costs of the Section 1101 experimental hiring program. ($ 31.387 Million)

RDT&E BUDGET ITEM JUSTIFICATION SHEET (R-2 Exhibit)	DATE September 1999
APPROPRIATION/BUDGET ACTIVITY RDT&E, Defense-wide BA6 Management Support	R-1 ITEM NOMENCLATURE Management Headquarters (Research and Development) PE 0605898E

(U) **FY 2001 Plans:**

- DARPA will continue to fund civilian direct-hires, both career and Section 1101 employees, and administrative support costs. Expanded Departmental and Federal Security requirements and anticipated pay raise requirements are also funded. ($ 34.632 Million)

(U) **Program Change Summary:** (*In Millions*)

	FY1999	FY 2000	FY 2001
Previous President's Budget	38.498	31.387	32.632
Current Budget	32.898	31.387	34.632

(U) **Change Summary Explanation:**

FY 1999 Decrease reflects removal of IPA costs from this PE to program funds, partially offset by the increased salary requirements of the expanded hiring authority.

FY 2001 Increase reflects mandated pay raises and additional security requirements.

(U) **Other Program Funding Summary Cost:**

- Not Applicable.

(U) **Schedule Profile:**

- Not Applicable.

SECTION III

MANPOWER

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
FY 2001 Budget Estimates Submission
BUDGETED MILITARY AND CIVILIAN PAY RAISE AMOUNTS
($ IN THOUSANDS)

	Effective	Percent	FY 1999	FY 2000	FY 2001
MILITARY PERSONNEL	N/A		0	0	0
CIVILIAN PERSONNEL					
RDT&E Defensewide					
Classified					
FY 1999	1-Jan-99	3.6%	341	455	455
FY 2000	1-Jan-00	4.4%	0	480	640
FY 2001	1-Jan-01	3.9%	0	0	531
Total			341	935	1626
TOTAL CIVILIAN PERSONNEL			341	935	1,626

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
CIVILIAN PERSONNEL HIRING PLAN
FY1999

APPROPRIATION: RDT&E, DEFENSEWIDE

			Separations						
Month	E/S Beginning	Gains	Attrition	Retire	RIF	Total	Net Change	E/S Revised	FTE
a	b	c	d	e	f	g	h	I	j
Oct	134	1	0	0	0	0	1	135	11
Nov	135	1	0	0	0	0	1	136	11
Dec	136	1	2	2	0	4	-3	133	11
Jan	133	1	0	1	0	1	0	133	11
Feb	133	3	0	0	0	0	3	136	11
Mar	136	2	0	2	0	2	0	136	11
Apr	136	2	0	0	0	0	2	138	11
May	138	0	0	0	0	0	0	138	12
Jun	138	1	0	0	0	0	1	139	12
Jul	139	1	0	0	0	0	1	140	12
Aug	140	1	0	0	0	0	1	141	12
Sep	141	0	0	0	0	0	0	141	13
Total	141	14	2	5	0	7	7	141	138

Exhibit PB-54 Civilian personnel Hiring Plan

CIVILIAN PERSONNEL HIRING PLAN
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
FY 2000

APPROPRIATION: RDT&E, DEFENSEWIDE

			Separations						
Month	E/S Beginning	Gains	Attrition	Retire	RIF	Total	Net Change	E/S Revised	FTE
a	b	c	d	e	f	g	h	I	j
Oct	141	7	0	0	0	0	7	148	12
Nov	148	6	1	0	0	1	5	153	12
Dec	153	2	1	2	0	3	-1	152	12
Jan	152	5	2	2	0	4	1	153	13
Feb	153	4	0	0	0	0	4	157	13
Mar	157	4	0	0	0	0	4	161	13
Apr	161	2	2	0	0	2	0	161	13
May	161	5	0	0	0	0	5	166	14
Jun	166	1	2	0	0	2	-1	165	14
Jul	165	3	3	0	0	3	0	165	14
Aug	165	1	3	0	0	3	-2	163	15
Sep	163	0	1	0	0	1	-1	162	15
Total	163	40	15	4	0	19	21	162	160

Exhibit PB-54 Civilian Personnel Hiring Plan

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
CIVILIAN PERSONNEL HIRING PLAN
FY 2001

APPROPRIATION: RDT&E, DEFENSEWIDE

Month	E/S Beginning	Gains	Separations: Attrition	Separations: Retire	Separations: RIF	Total	Net Change	E/S Revised	FTE
a	b	c	d	e	f	g	h	I	j
Oct	163	2	0	0	0	0	2	165	13
Nov	165	1	0	0	0	0	1	166	13
Dec	166	0	2	2	0	4	-4	162	13
Jan	162	1	1	1	0	2	-1	161	12
Feb	161	1	0	0	0	0	1	162	13
Mar	162	2	0	0	0	0	2	164	13
Apr	164	1	1	0	0	1	0	164	13
May	164	3	1	0	0	1	2	166	14
Jun	166	2	2	0	0	2	0	166	14
Jul	166	1	2	0	0	2	-1	165	14
Aug	165	1	3	0	0	3	-2	163	14
Sep	163	0	2	0	0	2	-2	161	13
Total	163	15	14	3	0	17	-2	161	159

Exhibit PB-54 Civilian Personnel Hiring Plan

Research, Development, Test, and Evaluation, DW | Date: September, 1999

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
CIVILIAN PERSONNEL COSTS
FY 2001 Budget Estimates Submission
FY 1999
($ in Thousands)

	Begin Strength	End Strength Total	End Strength FTP	Full-Time Equivalent Workyears Total	Full-Time Equivalent Workyears FTP	Basic Compensation	Overtime Pay	Holiday Pay	Other O.C.11	Total Variables	Total Compensation O.C.11	Benefits O.C.12	Compensation & Benefits
1. Direct Hire Civilian:													
a. U. S. Employees:													
(1) Classified and Administrative													
(a) Senior Executive Schedule	17	18	16	13	11	1,541	0	0	163	163	1,704	293	1,997
(b) General Schedule	117	116	106	120	113	9,080	36	0	221	257	9,337	1,725	11,062
(c) Special Schedule (1101)	0	7	7	5	5	625	0	0	25	25	650	119	769
Subtotal	134	141	129	138	129	11,246	36	0	409	445	11,691	2,137	13,828
(Rate)						81,493				(0.0396)	(84,717)	(0.1900)	100,203
(2) Wage System	0	0	0	0	0	0	0	0	0	0	0	0	0
(Rate)													
(3) Other													
(Rate)													
Subtotal United States	134	141	129	138	129	11,246	36	0	409	445	11,691	2,137	13,828
(Rate)						81,493				(0.0396)	(84,717)	(0.1900)	100,203
b. Direct Hire Foreign Nationals													
(Rate)													
c. Total Direct Hire	134	141	129	138	129	11,246	36	0	409	445	11,691	2,137	13,828
(Rate)						81,493				(0.0396)	(84,717)	(0.1900)	100,203
2. Indirect Hire Foreign Nationals	0	0	0	0	0	0					0	0	0
(Rate)													
3. Foreign National Separation Liability Accrual													
a. Direct Hire Foreign Nationals													
b. Indirect Hire Foreign Nationals													
4. Benefits for Former Employees(OC-13):													
a. Foreign National Direct Hire													
b. U.S. Direct Hire													
c. Voluntary Separation Pay											100		100
d. $80 Surcharge											0		0
e. Percent Early Retirement													
5. TOTAL CIVILIAN PERSONNEL	134	141	129	138	129	11,246	36	0	409	445	11,691	2,137	13,928
(Rate)						81,493				(0.0396)		(0.1900)	100,928
6. Reimbursable Data													
a. U.S. Direct Hires	0	0	0	0	0	0	0	0	0	0	0	0	0
b. Foreign National Direct Hires													
c. Total Direct Hires	0	0	0	0	0	0	0	0	0	0	0	0	0
d. Indirect Hire Foreign Nationals						0					0	0	
e. TOTAL REIMBURSABLE FUNDING	0	0	0	0	0	0	0	0	0	0	0	0	0
7. DIRECT FUNDED CIVILIAN PERSONNEL	134	141	129	138	129	11,246	36	0	409	445	11,691	2,137	13,928
(Rate)						81,493				(0.0396)	(84,717)	(0.1900)	100,928

Research, Development, Test, and Evaluation, DW

Date: September, 1999

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
CIVILIAN PERSONNEL COSTS
FY 2001 Budget Estimates Submission
FY 2000
($ in Thousands)

	Begin Strength	End Strength Total	End Strength FTP	Full-Time Equivalent Workyears Total	Full-Time Equivalent Workyears FTP	Basic Compensation	Overtime Pay	Holiday Pay	Other O.C.11	Total Variables	Total Compensation O.C.11	Benefits O.C.12	Compensation & Benefits
1. Direct Hire Civilian:													
a. U. S. Employees:													
(1) Classified and Administrative													
(a) Senior Executive Schedule	18	24	22	22	21	2,723	0	0	209	209	2,932	545	3,477
(b) General Schedule	116	119	114	119	116	9,400	40	0	520	560	9,960	1,880	11,840
(c) Special Schedule	7	20	20	19	19	2,480	0	0	325	325	2,805	496	3,301
Subtotal	141	163	156	160	156	14,603	40	0	1,054	1,094	15,697	2,921	18,618
(Rate)						91,269				(0.0749)	(98,106)	(0.2000)	116,363
(2) Wage System	0	0	0	0	0	0	0	0	0	0	0	0	0
(Rate)													
(3) Other													
(Rate)													
Subtotal United States	141	163	156	160	156	14,603	40	0	1,054	1,094	15,697	2,921	18,618
(Rate)						91,269				(0.0749)	(98,106)	(0.2000)	116,363
b. Direct Hire Foreign Nationals													
(Rate)													
c. Total Direct Hire	141	163	156	160	156	14,603	40	0	1,054	1,094	15,697	2,921	18,618
(Rate)						91,269				(0.0749)	(98,106)	(0.2000)	116,363
2. Indirect Hire Foreign Nationals	0	0	0	0	0	0					0	0	0
(Rate)													
3. Foreign National Separation Liability Accrual													
a. Direct Hire Foreign Nationals													
b. Indirect Hire Foreign Nationals													
4. Benefits for Former Employees (OC-13):													
a. Foreign National Direct Hire													
b. U.S. Direct Hire													
c. Voluntary Separation Pay											100		100
d. $80 Surcharge											0		0
e. Percent Early Retirement													
5. TOTAL CIVILIAN PERSONNEL	141	163	156	160	156	14,603	40	0	1,054	1,094	15,697	2,921	18,718
(Rate)						91,269				(0.0749)		(0.2000)	116,988
6. Reimbursable Data													
a. U.S. Direct Hires	0	0	0	0	0	0	0	0	0	0	0	0	0
b. Foreign National Direct Hires													
c. Total Direct Hires	0	0	0	0	0	0	0	0	0	0	0	0	0
d. Indirect Hire Foreign Nationals						0					0	0	
e. TOTAL REIMBURSABLE FUNDING	0	0	0	0	0	0	0	0	0	0	0	0	0
7. DIRECT FUNDED CIVILIAN PERSONNEL	141	163	156	160	156	14,603	40	0	1,054	1,094	15,697	2,921	18,718
(Rate)						91,269				(0.0749)	(98,106)	(0.2000)	116,988

Research, Development, Test, and Evaluation, DW

Date: September, 1999

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
CIVILIAN PERSONNEL COSTS
FY 2001 Budget Estimates Submission
FY 2001
($ in Thousands)

	Begin Strength	End Strength Total	End Strength FTP	Full-Time Equivalent (Workyears Total	Full-Time Equivalent (Workyears FTP	Basic Compensation	Overtime Pay	Holiday Pay	Other O.C.11	Total Variables	Total Compensation O.C.11	Benefits O.C.12	Compensation & Benefits
1. Direct Hire Civilian:													
a. U. S. Employees:													
(1) Classified and Administrative													
(a) Senior Executive Schedule	24	24	22	23	21	2,957	0	0	230	230	3,187	591	3,778
(b) General Schedule	119	118	113	117	115	9,603	50	0	560	610	10,213	1,921	12,134
(c) Special Schedule	20	20	20	19	19	2,576	0	0	190	190	2,766	515	3,281
Subtotal	163	162	155	159	155	15,136	50	0	980	1,030	16,166	3,027	19,193
(Rate)						95,195				(0.0680)	(101,673)	(0.2000)	120,711
(2) Wage System	0	0	0	0	0	0	0	0	0	0	0	0	0
(Rate)													
(3) Other													
(Rate)													
Subtotal United States	163	162	155	159	155	15,136	50	0	980	1,030	16,166	3,027	19,193
(Rate)						95,195				(0.0680)	(101,673)	(0.2000)	120,711
b. Direct Hire Foreign Nationals													
(Rate)													
c. Total Direct Hire	163	162	155	159	155	15,136	50	0	980	1,030	16,166	3,027	19,193
(Rate)						95,195				(0.0680)	(101,673)	(0.2000)	120,711
2. Indirect Hire Foreign Nationals	0	0	0	0	0	0					0	0	0
(Rate)													
3. Foreign National Separation Liability Accrual													
a. Direct Hire Foreign Nationals													
b. Indirect Hire Foreign Nationals													
4. Benefits for Former Employees(OC-13):													
a. Foreign National Direct Hire													
b. U.S. Direct Hire													
c. Voluntary Separation Pay											100		100
d. $80 Surcharge											0		0
e. Percent Early Retirement													
5. TOTAL CIVILIAN PERSONNEL	163	162	155	159	155	15,136	50	0	980	1,030	16,166	3,027	19,293
(Rate)						95,195				(0.0680)		(0.2000)	121,340
6. Reimbursable Data													
a. U.S. Direct Hires	0	0	0	0	0	0	0	0	0	0	0	0	0
b. Foreign National Direct Hires													
c. Total Direct Hires	0	0	0	0	0	0	0	0	0	0	0	0	0
d. Indirect Hire Foreign Nationals						0					0	0	
e. TOTAL REIMBURSABLE FUNDING	0	0	0	0	0	0	0	0	0	0	0	0	0
7. DIRECT FUNDED CIVILIAN PERSONNEL	163	162	155	159	155	15,136	50	0	980	1,030	16,166	3,027	19,293
(Rate)						95,195				(0.0680)	(101,673)	(0.2000)	121,340

SECTION IV

OTHER REQUIRED EXHIBITS

Advisory and Assistance Services

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

Appropriation: RDT&E Defense-wide	FY 1999 Actuals	FY 2000 Estimate	FY 2001 Estimate
	(Dollars in Thousands)		
1 Management & Professional Support Services			
FFRDC Work	0	0	0
Non-FFRDC Work	53,100	55,100	55,100
Subtotal	53,100	55,100	55,100
2 Studies, Analysis, & Evaluations			
FFRDC Work	7,000	7,000	7,000
Non-FFRDC Work	2,900	2,900	2,900
Subtotal	9,900	9,900	9,900
3 Engineering & Technical Services			
FFRDC Work	0	0	0
Non-FFRDC Work	0	0	0
Subtotal	0	0	0
TOTAL	**63,000**	**65,000**	**65,000**
FFRDC Work	**7,000**	**7,000**	**7,000**
Non-FFRDC Work	**56,000**	**58,000**	**58,000**

Prepared by: J. King
(703) 696-7533
9/10/99

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
EMPLOYEE RELOCATION EXPENSES

(DOLLARS IN THOUSANDS)

	FY 1999			FY 2000			FY 2001		
APPROPRIATION	Direct	Reimb	Total	Direct	Reimb	Total	Direct	Reimb	Total
1. RDT&E, DW	10		10	10		10	10		10
TOTAL	**10**		**10**	**10**		**10**	**10**		**10**

Contract Reporting by Appropriation
($Millions)
Defense Advanced Research Projects Agency

	FY 1999			FY 2000			FY 2001		
Appn	Total Contracts	Other Services Contracts	% of Total Contracts	Total Contracts	Other Services Contracts	% of Total Contracts	Total Contracts	Other Services Contracts	% of Total Contracts
0400D	1802.0	5.5	0.31%	1958.5	5.5	0.28%	1871.9	5.6	0.30%
0400R	27.1	0	0	25.0	0	0	25.0	0	0

Prepared by: Jerry King
703-696-7533
9/16/99

DEPARTMENT OF DEFENSE MANAGMENT HEADQUARTERS AND HEADQUARTERS SUPPORT ACTIVITIES

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

	FY 1999 Actual				FY 2000 Estimate				FY 2001 Estimate			
	Mil Avg Str	Civ FTEs	Tot Mpwr	Total Oblig ($000)	Mil Avg Str	Civ FTEs	Tot Mpwr	Total Oblig ($000)	Mil Avg Str	Civ FTEs	Tot Mpwr	Total Oblig ($000)
Departmental Activities												
Military Services												
Military												
U.S. Army	3		3	234	3		3	245	3		3	255
U.S. Navy	3		3	248	3		3	260	3		3	272
U.S. Air Force	12		12	930	12		12	974	12		12	1008
			18	1,412			18	1,479			18	1,535
Defense Agencies												
RDT&E Defensewide												
Civilian												
Direct Hire (Hdqtrs)		92	92	9,241		91	91	10,602		90	90	10,908
Direct Hire (Non Hdqtr)		46	46	4,587		69	69	8,016		69	69	8,285
Other Costs				19,070				12,769				15,439
			138	32,898			160	31,387			159	34,632
GRAND TOTAL			156	34,310			178	32,866			177	36,167

POC: Kelly Archer Phone: 696-0242
Date: September, 1999

Exhibit PB-22

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
SUMMARY OF FUNDS BUDGETED FOR ENVIRONMENTAL PROJECTS
FY 2001 BUDGET ESTIMATE SUBMISSION
($, Thousands)

Environmental Security Technology		FY 1999 Actual	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	*Change FY 00/01*	*Change FY 01/02*
Appropriation:	RDT&E Defense-wide						
1. Cleanup	Not Applicable						
2. Compliance	Not Applicable						
3. Pollution Prevention	BA2 - Applied Research: Thin Film Coatings Program	2,494	345	0	0	*-345*	*0*
4. Conservation	Not Applicable						
Total		2,494	345	0	0	-345	0

Justification for Changes The funding changes reflect contractual requirements. DARPA environmental efforts end in FY 2000.

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
FY 2001 BUDGET ESTIMATES SUBMISSION
COMPETITION AND PRIVATIZATION

A negative reply is submitted for DARPA. There are neither civilian nor military positions which are subject to competition or direct conversion under the A-76 process.

Component: DARPA

INTERNATIONAL TRAVEL

Point of Contact: Kelly R. Archer, (703) 696-0242

Date: September 1999

	FY 1999
Total Obligations ($ in millions):	$0.264
Total Number of individuals:	49

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
RDT&E, DEFENSE-WIDE
OBJECT CLASSIFICATION
($ IN THOUSANDS)

	FY 1999 Actual	FY 2000 Estimate	FY 2001 Estimate
Personnel Compensation			
11.1 Full-Time Permanent	11,101	14,408	14,935
11.3 Other Than Full-Time Permanent	145	195	201
11.5 Other Personnel Compensation	409	1,054	980
Total Personnel Compensation	11,655	15,657	16,116
Direct Obligations			
11.9 Total Personnel Compensation	11,655	15,657	16,116
12.0 Civilian Personnel Benefits	2,137	2,921	3,027
13.0 Benefits for Former Personnel	100	100	100
21.0 Travel and Transportation of Persons	2,879	2,925	2,972
22.1 Transportation of Things	10	10	10
23.1 Rental Payments to GSA	2,443	2,482	2,522
23.2 Rental Payments to Others	148	150	152
23.3 Communications, Utilities and Miscellaneous Charges	731	743	755
24.0 Printing and Reproduction	15	15	15
25.1 Advisory & Assistance Services	63,000	65,000	65,000
25.2 Other Services	5,457	5,544	5,633
25.5 R&D Contracts	1,733,557	1,888,002	1,801,290
26.0 Supplies and Materials	715	726	738
31.0 Equipment	2,519	3,677	3,352
Total Direct Obligations	1,825,366	1,987,952	1,901,682
Reimbursable Obligations			
25.5 R&D Contracts	27,120	25,000	25,000
Total Obligations	1,852,486	2,012,952	1,926,682